IMPACT OF A FOURTEENTH CENTURY EL NIÑO FLOOD ON AN INDIGENOUS POPULATION NEAR ILO, PERU

BY

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To Carole (D.L.)--The Wind Beneath My Wings

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A number of figures were adapted from the works of others including the following: Figure 1-5 was adapted from Clement and Moseley 1991; Figure 2-2 was adapted from Dillon 1985; Figure 2-3 was adapted from S.P.C.C. 1985; Figure 3-2 was adapted from Moseley 1992; Figure 3-5 was adapted from Silgado 1978; Figures 5-14 and 7-26 were adapted from original drawings made by Nikki Clark, with additional interpretations by Michael E. Moseley and Jorge Tapia. Figures 7-11 and 7-12 were adapted from original field drawings made by Karen Wise and myself in 1990. Of course, any errors in translations and interpretations are solely my responsibility.

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TABLE OF CONTENTS

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

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Chairman: Professor Michael Moseley
Major Department: Anthropology

A strong El Niño-Southern Oscillation (ENSO) is the only natural phenomenon which can slow the earth's rotation and disrupt global climate and rainfall patterns for a year or more, potentially altering a culture's subsistence base. Some of these El Niños are Pan-Andean catastrophes that have stochastically occurred for approximately 5,000 years. If a strong El Niño flood wrecks havoc upon the modern population along the Peruvian littoral, the possible consequences of an even stronger event could have been devastating to the prehistoric indigenous populations of southern Peru.

This dissertation is based on my investigations of the largest, late prehistoric El Niño flood yet identified in the southern Andes of Peru. The research was conducted in three coastal quebradas--normally dry drainages--and in the Ilo Valley near the modern fishing port of Ilo, Peru (17° S. Lat.) during the summers of 1990-1992.

The focus here is to assess the impact of this inordinately large El Niño flood (ca. 1350 A.D.) on the irrigated agrarian systems and settlements located within the study area and to analyze the stress upon the resident Chiribaya Culture (ca. 1000-1350 A.D.). The purpose was to test the hypothesis that the Miraflores Flood had ultimately led to the demise of this culture.

Analysis of the frequencies of the recovered data support my original hypothesis. Investigations also led to the identification of a new phenomenon, which I have called a "SCDE" (Synergistically Coupled Destructive Event), which combines the forces of seismic events and El Niño floods into a whole, that far exceeds the sum of its parts in destructive power. In this case, a prehistoric SCDE must have formed a massive wall of mud five to six meters high, which roared down the mountains at 113 k.p.h., totally obliterating the Chiribaya Culture at the Miraflores Quebrada as it swept every trace of their village into the Pacific Ocean. In other areas, it so crippled their infrastructure of agricultural terraces and irrigation canals that the Chiribaya who managed to survive the SCDE disaster, sank into a permanent cultural decline.

CHAPTER 1

INTRODUCTION

Purpose of Study

The purpose of this study is to assess the impact of a 14^{th} century flood event on the agricultural infrastructure of the prehistoric indigenous population of the Chiribaya Culture and to test the hypothesis that this flood ultimately led to the demise of the Chiribaya Culture of the Osmore Drainage in extreme southern Peru (Figure 1-1). This group occupied and farmed three coastal quebradas (normally dry valleys) of Carrizal, Miraflores, and Pocoma, and the Ilo Valley from about 1000-1350 A.D. In order to discover evidence of this enormous flood event, which occurred about 1350 A.D. (PITT 0948), research was conducted from 1990-1992. The study area in southern Peru included the 3 quebradas, located North of the modern fishing port of Ilo and the Ilo Valley, located 5 km North of this same city at 17° S. Lat. (Figure 1-2)

The Chiribaya were an autonomous group (Jessup 1991) which used available river and spring flow to irrigate terraced fields in the research area. This same group constructed a 9 km-long canal which was used to irrigate the largest agricultural system ever built in the lower Ilo Valley (Satterlee 1991; Figure 1-3). Both of these areas demonstrate the dramatic impact of the same prehistoric flood event on the Chiribaya Culture.

Figure 1-1: Osmore Drainage in Extreme Southern Peru

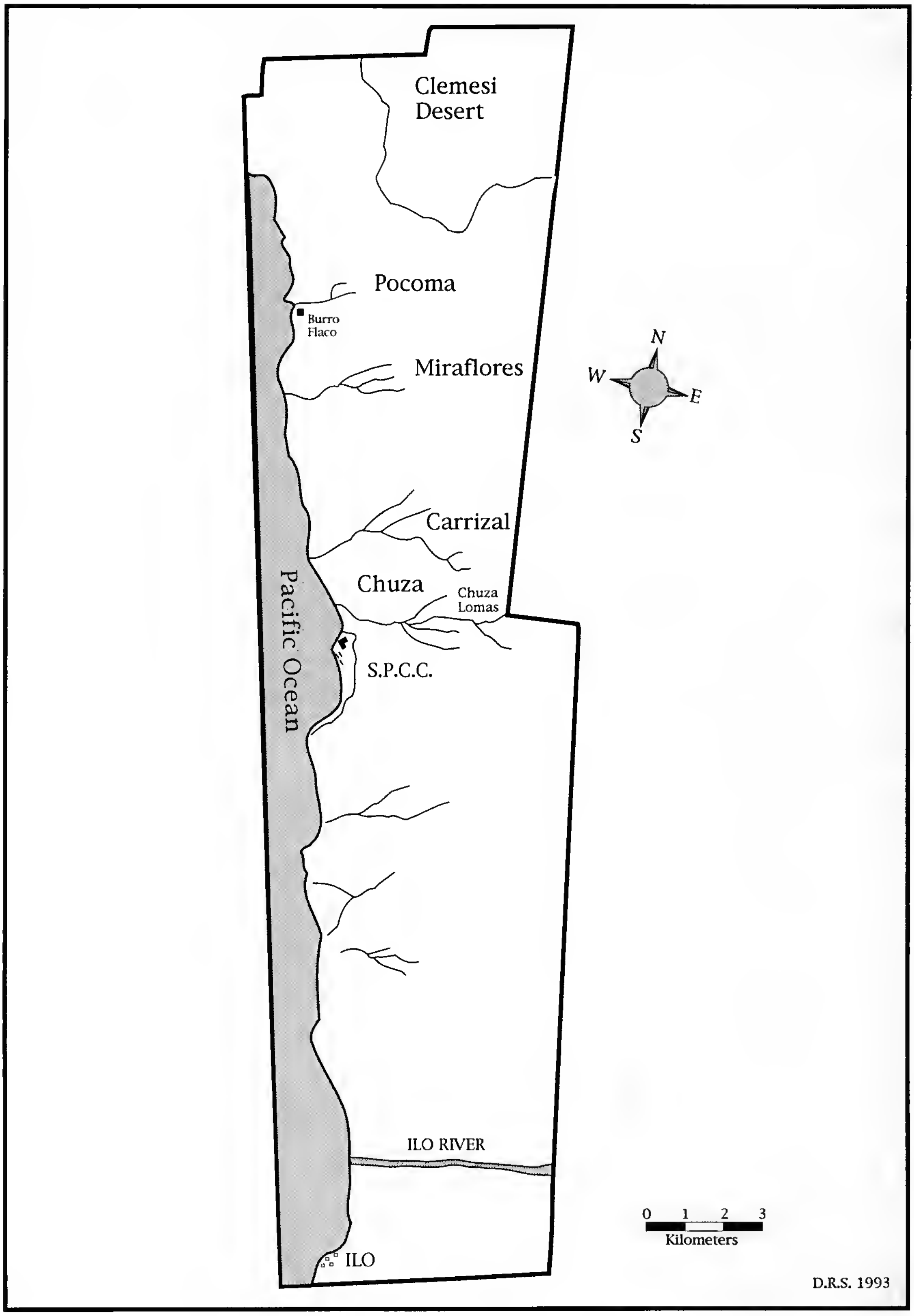


Figure 1-2: The Ilo Coastline

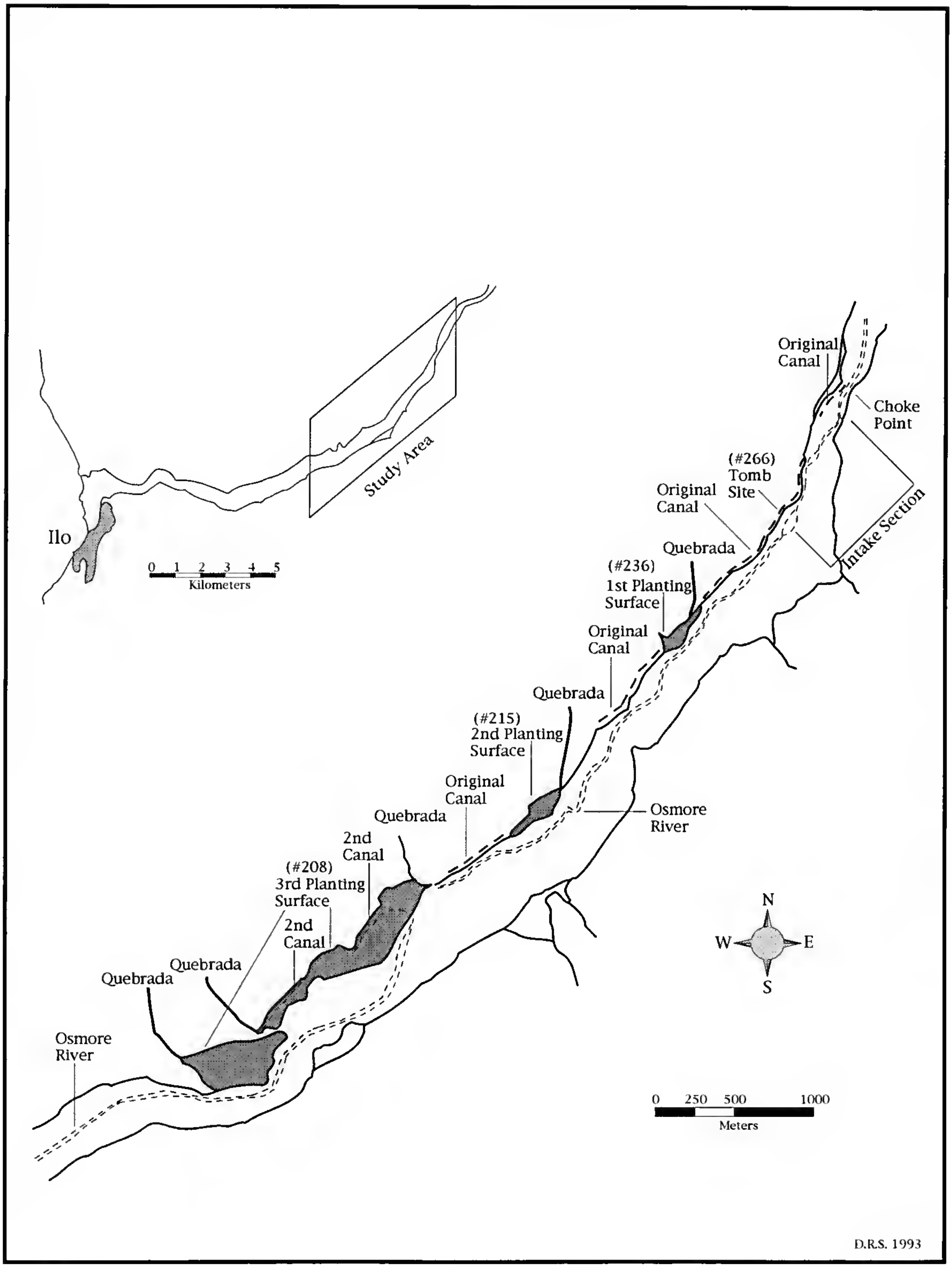


Figure 1-3: Chiribaya Irrigated Agricultural System--Ilo Valley

Physical Setting

Extreme Southern Peru

Peru is located on the coast of South America, and it shares common borders with Columbia and Ecuador to the north, with Brazil and Bolivia to the east, and with Argentina and Chile to the south (Figure 1-1). Although the Pacific littoral of Peru is the driest desert in the New World (Lettau and Lettau 1978), it was home to some of the most advanced civilizations in the Western Hemisphere, including the Moche, Chimu, and the Inka.

In the dry altiplano of the southern Andes, the Tiwanaku Empire held sway over most of the region for almost an entire millennium. About 70 km from the study area, near Moquegua, several outlying settlements with Tiwanaku affiliations have been identified and studied (Goldstein 1989).

Peru is a country with ecological extremes. Much of it can be divided into three distinct zones, i.e. the western dry coastal desert with intermittent oases; the lush, humid tropical lowlands to the east; and the intensely cold, high altiplano ringed by the Andean Cordillera. These areas were occupied by scattered, mostly autonomous, indigenous communities, many of which interacted while practicing Ecological Complementarity (verticality), i.e. the exchange of products between the different zones where only certain crops could be grown because of a difference in the altitude. (Murra 1978; Stanish 1992).

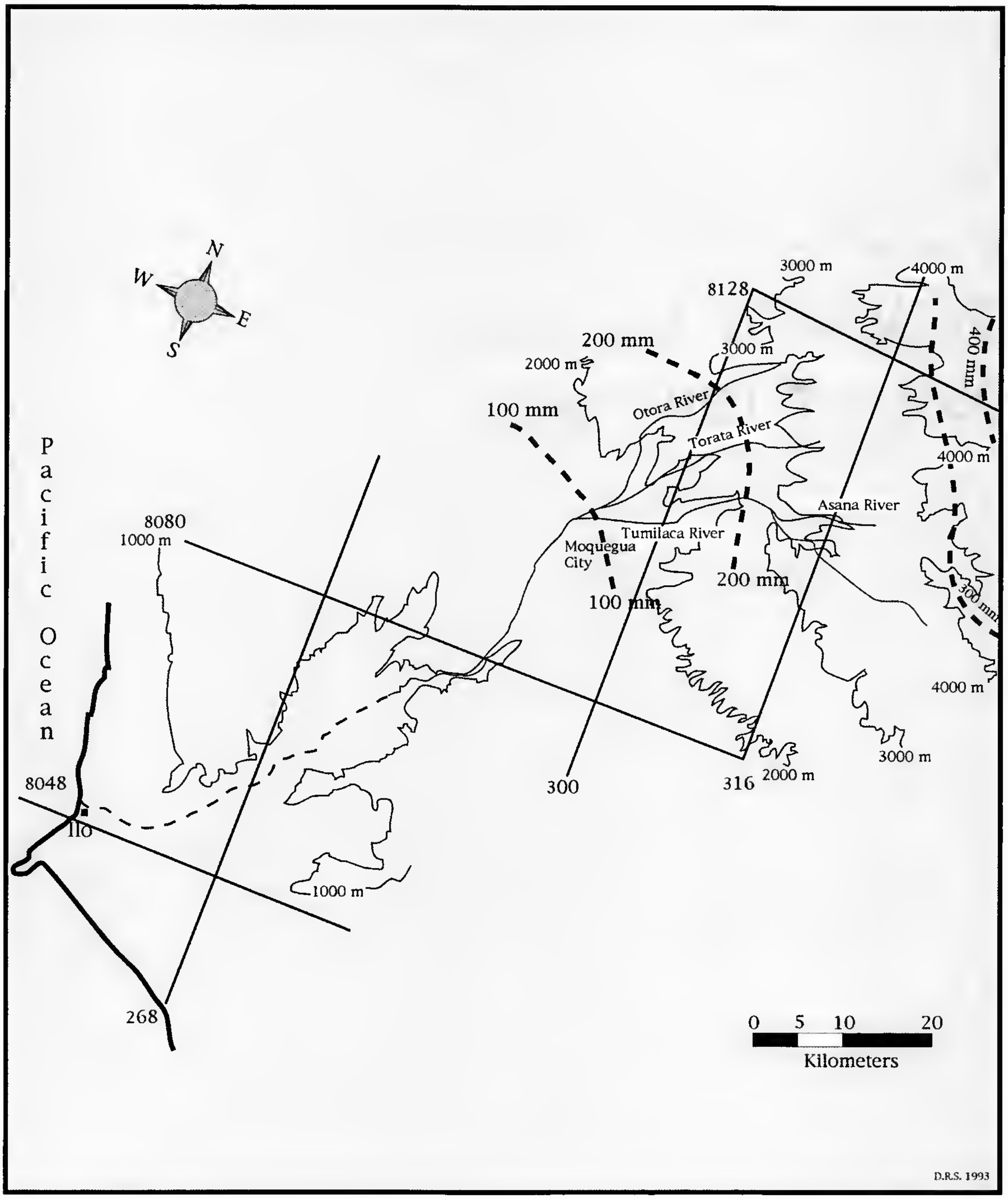
Extreme southern Peru is generally known as the coasts of the Departments of Moquequa and Tacna, which lie between the Tambo and Izapa Valleys--16°30'-18°30' South Latitude and 69°30'-72° East

Longitude. It is an area limited to the north by the highlands of Arequipa and to the south by the Chilean border. It is bounded by the Pacific Ocean on the west and by the high eastern Cordillera of the Andes on the east. Archaeologically, this area has been one of the least known in all of Peru (Vescelius 1960).

Much of this region was home to the Chiribaya Culture between the years of 1000-1350 A.D. Through a bit of serendipity, some of the Chiribaya remains were uncovered by the Tsunami of 1868, but it was not until 1956 that the Chiribaya Culture was first identified by Humberto Ghersi Berrera (1956). Ghersi excavated seven unlooted tombs in the cemetery that is now called "Chiribaya Baja," and he located several Chiribaya sites between the valley and the mouth of the Ilo River (1956:90). Typical grave goods found were decorated ceramics, woven sacks containing grain, food stuffs, herbs, and coca leaves, panpipes, and some textiles (1956:107-110).

The territory from 500 m to 2,500 m of the Chiribaya homeland is characterized, by some, as being unhealthy because maladies, such as *Uta* (a form of leishmaniasis), *Verruga* (weeping skin ulcers), goiter, and malaria are often found at these elevations (Belan 1981). Despite the presence of these diseases, cultural occupation extended from the edge of the Pacific coast up to an elevation of 2,500 m, but the majority of Chiribaya artifacts are found from sea level up to 1,000 m (1981:23; Stanish 1992).

Situated in the southern Andes, the Osmore Drainage (Figure 1-4), which includes the upvalley Moquegua River and the downvalley Ilo River, is a long, narrow valley (125 x 25 km) that covers slightly



(Note: Universal Transverse Mercator coordinates in meters)
Figure 1-4: Average Annual Precipitation--Osmore Drainage

less that 3,500 km^2 with a population of about 70,000 (Rice and Watanabe 1989). The geology of the drainage, like other Peruvian coastal valleys, is composed of sedimentary, metamorphic, and igneous rocks dating from the Cenozoic eras (McCreary and Koretsky 1966). The drainage can be conveniently divided into three sections according to the highly variable precipitation influenced by a change in altitude. While most of the central and northern coasts of Peru receive an annual rainfall varying from 15-40 mm (Moore 1991:29), the coast at Ilo is somewhat drier and receives annual rainfall of only 5 mm (McCreary and Koretsky 1966). In the Moquegua region (1400 m), the average rainfall increases to 100 mm. It is only at 3,900 m and above that the precipitation is 250 mm or more (ONERN 1976; S.P.C.C. 1985; Figure 1-4).

The Osmore River begins its flow as the Rio Asana at 5,100 m. At Moquegua other smaller tributaries join to form the larger Rio Moquegua. The lower 20 km of the river system is the spring-fed Rio Ilo that is separated from the upper Moquegua Drainage by 35 km of dry river channel because the upper river flow disappears underground at a higher elevation of about 1200 m. Only during the years of particularly heavy highland precipitation does the lower Ilo channel experience river flow, which helps to recharge the local aquifer and to source seeps and springs. The last 20 km of the drainage system has sparse natural vegetation and some feral cotton, but the coastline is mostly devoid of any natural vegetation.

Scientific research began in Peru in the early 1900s (Uhle 1910), but until the early 1980s, when the Programa Contisuyu began its interdisciplinary, multi-institutional research program in

the environs surrounding Ilo, little was known about far-southern Peru. Perhaps this area was neglected because it lacks the sometimes spectacular monumental architecture that is so prominently visible along much of the central and northern coasts of Peru. Although lacking in free-standing prehistoric architecture, this region is rife with archaeological sites.

The Coastal Quebradas

Introduction

In any desert environment, a reliable water source is the primary element needed to support agriculture. However, in the study area, the Carrizal springs supply the only regular freshwater source in the desert until one reaches the Tambo Valley, 8 km to the north (Bawden 1990). Today the quebrada contains a spring source that is 20+ meters lower in elevation than it was during the early Spanish Colonial Period (Figure 1-5; Clement and Moseley 1991). At the Miraflores Quebrada, a limited amount of irrigation water is pumped from a small reservoir. At the Pocoma Quebrada, the intermittent trickle of spring water is collected in a shallow concrete tank. Since the water supply at any of the coastal quebradas is meager, in order to provide sufficient irrigation water, it now must be stored in a reservoir in order to create enough volume and pressure to reach the scant remaining olive trees located downslope.

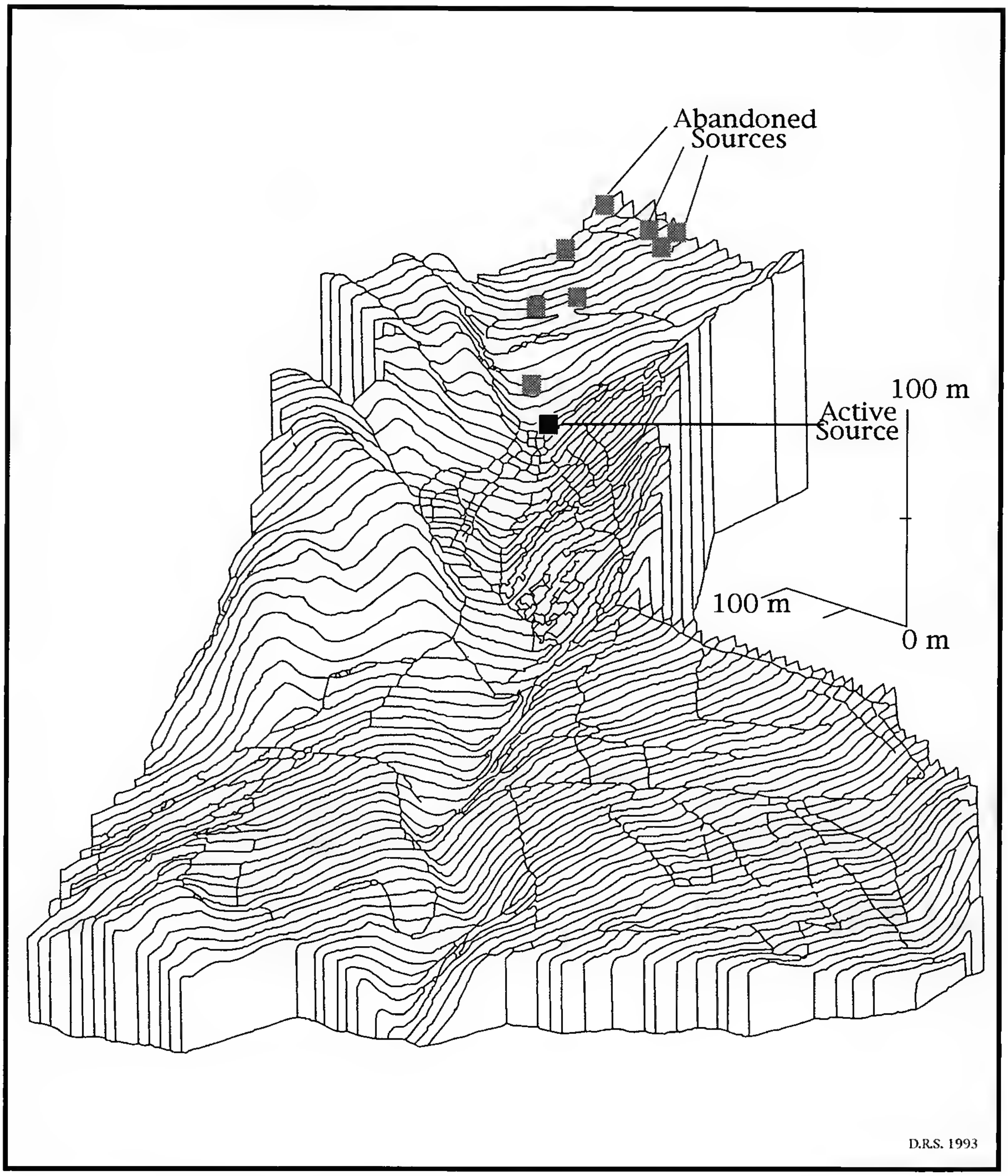


Figure 1-5: Water Table Drop at Carrizal Springs

Catchment Area

The "catchment" of a valley or quebrada is the total area of the watershed which collects rainfall and funnels it into the lower reaches of the valley or quebrada. The area of the catchment needs to be at least 15 times greater than the area which the water irrigates. Even then, this areal proportion is barely large enough to supply ample runoff for agrarian surfaces (Doolittle 1990:34). Unlike some of the northern valleys of Peru, which have permanent flowing rivers that were traditionally diverted from one river valley to another to increase the amount of water for agricultural purposes (Ortloff et al. 1982), far-southern Peru lacks such resources. Fortunately in some areas of the Ilo Valley and in the coastal quebradas there are springs, which can be used to augment whatever ephemeral flow came from the higher regions around Moquegua or above.

After some investigating, it was soon discovered that there were insufficient aerial photographs locally available to the author which could provide the coverage needed to calculate the total catchment area for the individual quebradas. It was hypothesized that these figures might show some correlation between the depth of the flood deposits found at a quebrada and the total catchment for the quebrada. However, this idea could not be tested with the accessible aerial photographs. Beginning with the Pocoma Quebrada, Figure 1-2 shows that the approximate catchment for each quebrada is about one-half of its neighbor to the south. Although the Carrizal Quebrada has the largest catchment, the spring flow is none too great

despite the fact that the aquifer should be adequately re-charged during each rainy season.

Carrizal Quebrada

Total Agricultural Area

The measurements of the agricultural and settlement areas were made using a planimeter, which is an instrument that can be used to calculate the area of a polygon of any shape. The numbers from the vernier scale of the planimeter are squared and then multiplied by a factor which is constant for each particular photo scale, yielding the number of hectares within a measured area. The accuracy of such measurements is dependent upon how closely one follows the outline of the polygon. Any slight deviation from a path will produce a different reading each time. Thus, several readings are usually taken and then averaged for a more accurate result. Since there are computer programs which will calculate both the perimeter and the area of a polygon in microseconds, using a planimeter is a somewhat antiquated method of measuring areas, but, nevertheless, the results are usually quite acceptable.

Based on the analysis of aerial photography, the total land used prehistorically for agriculture at the Carrizal Quebrada was approximately 25.86 ha, while the modern agricultural land used for olive cultivation accounted for 2.48 ha. Therefore, the percentage of land used by modern agriculture is 9.6% of the prehistoric land usage, which compares favorably with the results of a field study conducted by Clement and Moseley (1990a and 1990b, 1991), who concluded that the late modern agriculture accounted for only 6% of

the total land under cultivation compared prehistorical farming activities at the Carrizal Quebrada.

Settlement Size

It was difficult to make an exact determination of the location of the domestic areas at Carrizal because the quebrada has been farmed by the Spanish Colonialists as well as by modern farmers. Deciding on the extent of domestic areas was further complicated because at least one area may have been used before and after the Miraflores Flood. Lacking the data from house foundations or from mortuary estimates, it is almost impossible to estimate accurately the prehistoric native population which lived at Carrizal. Population figures from the ethnohistorical records such as the "*visitas*," (e.g. San Miguel 1567; Toledo 1570-75; Zuñiga 1562) are not too useful because it is a known fact that the native population declined by as much as 70-80% after the smallpox pandemic beginning in 1521 (Moseley 1992). Therefore, 1.65 ha, based on the measurements of two separate suspected domestic areas, is probably a reasonable estimate of the settlement size at the Carrizal Quebrada.

Miraflores Quebrada

Agricultural Area

At the Miraflores Quebrada, prehistoric agriculture encompassed an estimated 18.49 ha, while the late modern agriculture now covers only 8.83 ha. These figures mean that the decrease in total agricultural usage at this quebrada is 47.8%. This decline would seem to indicate that the total food production for the

Ilo region may have suffered substantially in the last few centuries. However, since most of the agricultural land in these three quebradas has been devoted entirely to olive production for over 400 years, much of the comestibles would have had to come from the highlands, as they do today.

Settlement Size

Although the domestic terraces of the village at the Miraflores locale are totally blanketed by flood deposits, the terraces are still easily delineated using stereo viewing of an aerial photograph. Furthermore, since the land was covered so completely by sediments, this settlement is one of the few places that neither colonial nor modern agriculture disturbed the domestic area. The settlement here measures approximately 140 m by 140 m or 1.96 ha, which is only slightly larger than the domestic areas at the Carrizal Quebrada.

Pocoma Quebrada

Agricultural Area

Pocoma Quebrada has the largest active olive grove for 20 km along the coast immediately north of Ilo. There are still 15 ha of olive trees growing here. This agricultural area still does not compare favorably to the 29.7 ha which was used for prehistoric agriculture. Thus, similar to the Miraflores Quebrada, the total area under cultivation at Pocoma Quebrada has decreased by slightly over 50% since the Chiribaya people farmed this area. The most alarming fact discovered while doing the analysis of the prehistoric and

modern cultivated areas at each quebrada was the vast difference in the total hectares under cultivation today compared to when the Chiribaya Culture occupied these quebradas. The most glaring example is the very small amount of modern agriculture at the Carrizal Quebrada, but this same pattern of less land being cultivated through time also holds true for the other two quebradas investigated.

Settlement Size

If all of what appears to be domestic terraces were once occupied, then the Pocoma Quebrada would have had the largest Chiribaya settlement, covering a total of 2.61 ha. Although there is evidence of the Miraflores Flood even at this highly elevated area (compared to the other two quebradas), the impact of the Miraflores Flood may not have affected the Chiribaya living here as directly or severely as it did elsewhere.

Chapter Summaries

Chapter 2 begins by discussing the causes of the global-impacting weather phenomenon known as the El Niño-Southern Oscillation (ENSO) and the associated changes in climatic regimes, such as torrential rains and exceptional drought. Further discussion includes the possible correlations between volcanic eruptions and the onset of an ENSO and between global warming and the frequency of

ENSOs. Also considered are the often severe effects of El Niño flooding on the Peruvian people, coastal and highland agriculture, domestic herding activities, and marine life. In conjunction with these adverse effects, the economic impact on Peru's predominant capital-generating enterprise, commercial fishing, and the related industry of fishmeal production is discussed. In an effort to offset some of the intense negativism, the positive consequences of a strong El Niño are also mentioned. The final topic discussed is the application of modern data in a prehistoric milieu.

Chapter 3 begins with a brief synopsis of each of the Periods and Horizons that are associated with significant cultural changes and achievements in Peruvian Prehistory. A good portion of this chapter is devoted to the important and often debated topic of the intensification and development of irrigated agriculture. Social changes associated with agriculture are also discussed. Some of the motivating factors which are credited with giving impetus to the development of agriculture are examined. The advantages of agricultural terracing, the use of fertilizers, and risk management, all of which are pertinent topics related to farming in the often hostile Peruvian environment, are also discussed. Discussion likewise includes how the agriculture-based prehistoric diet of Peru compares to the modern Peruvian diet. The difference between traditional and modern methods of water management are explored. A number of topics closely aligned with the relationship between religion and agriculture, such as the role of the gods in agriculture and oracles and religious centers, are investigated at length. A delineation of important environmental factors, including constant stresses and

periodic stresses, which adversely affect agriculture, is given. The final topics considered in this chapter are the previous flood studies conducted in Peru, the general prehistoric flood record in Peru, and the specific prehistoric flood record in the study areas of the Osmore/Ilo Valley and the coastal quebradas.

Chapter 4 discusses the methods used during the three field seasons in Peru. Field survey was used to search for potential sites and to analyze the flood impact to the domestic and agricultural areas. Excavation techniques, such as unit excavations, trenches, and shovel testing are discussed. Methods used to prepare the geologic columns, unit profiles, and canal cross sections for the transfer of pertinent features and information to graph paper are discussed. The methods for creating maps which contained the locations of units, trenches, and geologic columns are outlined. Laboratory techniques used to process materials from the field and their analysis are also explained. Methods used to recover carbon for ^{14}C dating are discussed. The final topics considered are the techniques used in creating computer maps, profiles, and illustrations from field drawings for inclusion in this dissertation.

Chapter 5 discusses a number of important aspects of my field work influencing decision making and interpretations. For example, the criteria for choosing the location of units and geologic columns is outlined. A brief description of the location of units, columns, and trenches and other pertinent data are given. What the excavations indicate about the severity of the Miraflores and Chuza Floods is discussed. Also discussed is what the archaeological record suggests

concerning the post-flood survival or demise of the Chiribaya people who occupied the study area.

Chapter 6 begins by discussing the types and quantities of cultural materials which could be expected to be found at each investigated locality. The main focus of this chapter are the data contained in the tables listing the artifactual materials recovered from each level of a particular unit, feature, geologic column, or midden. The total sherd distribution from each quebrada, the sherd distribution from the individual floods, and the sherd weight distribution per natural strata are analyzed in order to infer the relative strengths of the two flood episodes and the relative flood impact at each location. Several hypotheses are offered as possible explanations for the existing discrepancies in the sherd distributions. Finally, a discussion of the possible reasons for why the agricultural terraces near Ilo, Peru, were abandoned is presented.

Chapter 7 presents an analysis of the unit profiles and geologic columns. These data are analyzed to determine the composition of the Chuza and Miraflores Floods. The flood record and the stratigraphy are scrutinized to assess the consistency of the flood deposits found in the individual quebradas. Finally a discussion is presented concerning the depths of the flood deposition at each quebrada and at the specific locations where units and geologic columns are located in an effort to determine whether the deposits were found at a uniform depth at each investigated location.

Chapter 8 presents the summaries, syntheses, and conclusions of all the data gathered during the course of three field seasons in far-southern Peru. These data are analyzed to estimate the overall

impact of the Miraflores flood on the Chiribaya Culture. Further analysis includes the determination of whether or not the evidence supports the original thesis that the impact of the Miraflores Flood was of sufficient magnitude to destroy totally or partially the irrigated agricultural system which was the Chiribaya subsistence base. A scenario of a possible response by the Chiribaya people in the months following the flood devastation is presented. Possible recommendations are made which could help to improve or modify future flood investigations so that maximum information can be obtained, while at the same time using the minimum of amount of field time and spending the least amount of money on field assistants.

CHAPTER 2
EL NIÑO-SOUTHERN OSCILLATION

Introduction

Few, if any, natural phenomena have the global impact of an El Niño-Southern Oscillation (ENSO). A strong event can slow the rotation of the earth, alter the length of day, impact global climate, and create worldwide disasters (Salstein and Rosen 1983). Strong ENSOs can displace normal climatic regimes, especially in the Tropics, for periods lasting from a few months to a few years (Rasmusson 1984:5). The very strong 1982-83 El Niño caused record rainfall in California, severe spring flooding in the northern United States, record droughts in Africa (the worst of the century) and Australia, unusual wintertime conditions as far apart as the U.S.A. and New Zealand (Rasmusson 1984), and devastating rains and flooding along the western coast of South America (Caviedes 1984; Glantz, 1984; Tapley and Waylen 1989; Waylen and Caviedes 1986). This extraordinary event was the most prolonged and catastrophic El Niño ever recorded, surpassing the great El Niños of 1925 and 1891 (Rasmusson 1984:11; Glantz 1984). Although a strong El Niño affects humanity worldwide, the devastation is often most apparent along the Peruvian littoral (Figure 2-1). Here the torrential rains cross one of the driest deserts in the world (Lettau and Lettau 1978) and descend one of the steepest watersheds found anywhere--falling from 6,000 plus meters to sea level in a

Figure 2-1: The Peruvian Littoral

distance of a few hundred kilometers. Thus, severe flooding, flash floods, and immense mud slides are commonplace along the Peruvian littoral during strong ENSO events (Glantz 1984; Arntz 1984).

The purpose of this chapter is to explore the following: the causes of the stochastic weather phenomenon that has become known as the El Niño-Southern Oscillation; climatic changes--exceptional rainfall and drought--associated with strong El Niños; possible correlations between volcanic eruptions and the El Niño phenomenon; possible correlations between global warming and the frequency of El Niños; the effects of the ENSO-induced torrential rains and flooding; the subsequent impact on the Peruvian population, agriculture (both coastal and highland), domesticated herd animals, and marine life; economic impact; positive consequences of an El Niño; and, finally, the application of modern data to prehistoric settings.

Since the 1991-92 El Niño is continuing into this year (Sonja Guillen, personal communication 1993), this study of an extremely large Prehistoric event may help us better understand that some large 20th century ENSOs, which are viewed as very severe, are possibly but a harbinger of what may lie ahead for the inhabitants of the Peruvian coastline since there seems to be an increase in Strong to Very Strong events in the last two centuries based on historical records (Table 2-1).

Background Information

Because of the Colonial Spanish's penchant for keeping administration and litigation records, we have accounts of extreme rainfall and flooding in Peru as early as 1541 (Quinn et al. 1986). The selected El Niños presented in Table 2-1 are only those strong events that have a high confidence rating as determined by Quinn, et al., through a literature search of Spanish Colonial documents, early Spanish chroniclers and clerics, and other non-Hispanic, historical sources concerning Peru.

Table 2-1: Strong Historical El Niño Events

YEAR	STRENGTH	YEAR	STRENGTH	YEAR	STRENGTH
1541	S	1728	VS	1899-00	S
1552	S	1791	VS	1911-12	S
1567-68	S	1803-04	S+	1917	S
1578	VS	1828	VS	1925-26	VS
1607	S	1844-45	VS+	1932	S
1624	S+	1871	S+	1940-41	S
1652	S+	1877-78	VS	1957-58	S
1701	S+	1884	S+	1972-73	S
1720	S+	1891	VS	1982-83	VS

(Note: S=Strong; VS=Very Strong)

Although there has been information available for centuries concerning devastating Niño floods along the Peruvian coast, and good records exist for the 1891 event (Murphy 1926), it was not until the 1970s that evidence for strong events and their effects was widely presented to the public. Prior to this date, media coverage of the El Niño phenomenon, in any form, was virtually non-existent because the 1957-58 event was little known outside of Peruvian newspaper accounts, but the 1972-73 El Niño was the first to receive a great deal of worldwide attention because of the widespread droughts in West and East Africa, Ethiopia, the Soviet Union, Australia, and Central America that were associated with this perturbation (Glantz 1984:15-16). Because of the interest in this event, the recent media coverage given to the 1982-83 El Niño was so extensive that it might be believed by some that El Niños are 20th century weather phenomena. However, since 1979 (Nials et al.) El Niño flooding has been studied archaeologically, and recent geoarchaeological evidence suggests that the Peruvian desert coast has experienced massive flooding from cataclysmic El Niño rains for about 5,000 years (Sandweiss 1986; Rollins et al. 1986).

The Cause of El Niños

"The term El Niño (Little Christ Child) was coined long ago by Peruvian fishermen who witnessed the annual warming of the coastal waters just after Christmas" (Dillon 1985:6). An El Niño is, among other things, the appearance of uncommonly warm water along the coasts of Ecuador and Peru, which causes disastrous ecological and economic consequences. Although its effects have

been traced at least as far as the western equatorial Pacific, the manifestations of El Niños are especially dramatic along the Peruvian littoral (Smith 1983). This phenomenon, which can persist for 6 to 18 months (Thayer and Barber 1984), is much more involved than the simple occurrence of unusually warm water along the South American strand.

Before the actual onset of an El Niño, there are stronger than average easterlies in the western equatorial Pacific for at least 18 months. These winds tend to move water from the eastern Pacific toward the West as indicated by (a) in Figure 2-2, and consequently the sea level is usually higher in the West than in the East (Cane 1983). In September or October the easterlies begin to diminish along the equator west of the International Date Line, and subsequently this "dome" of warm water in the central Pacific, which is 2-3 meters higher than in the eastern Pacific, "sloshes back east colliding with Peru and overriding the cold Peruvian (Humboldt) Current" (also known as the South Equatorial Current) (Feldman 1983:17; (b) in Figure 2-2). At the same time, the thermocline in the West is depressed and becomes deeper than average by as much as 50 meters or more and the equatorial upwelling is, also, reduced (Smith 1983). Both local and remote responses to the wind contribute to rises in both sea level and sea-surface temperatures (SST) that are characteristic of El Niño (Cane and Zebiak 1985).

In the fall of the year preceding the 1983 Niño, SST anomalies varied from 3.5°C to 8°C above normal along the coast of

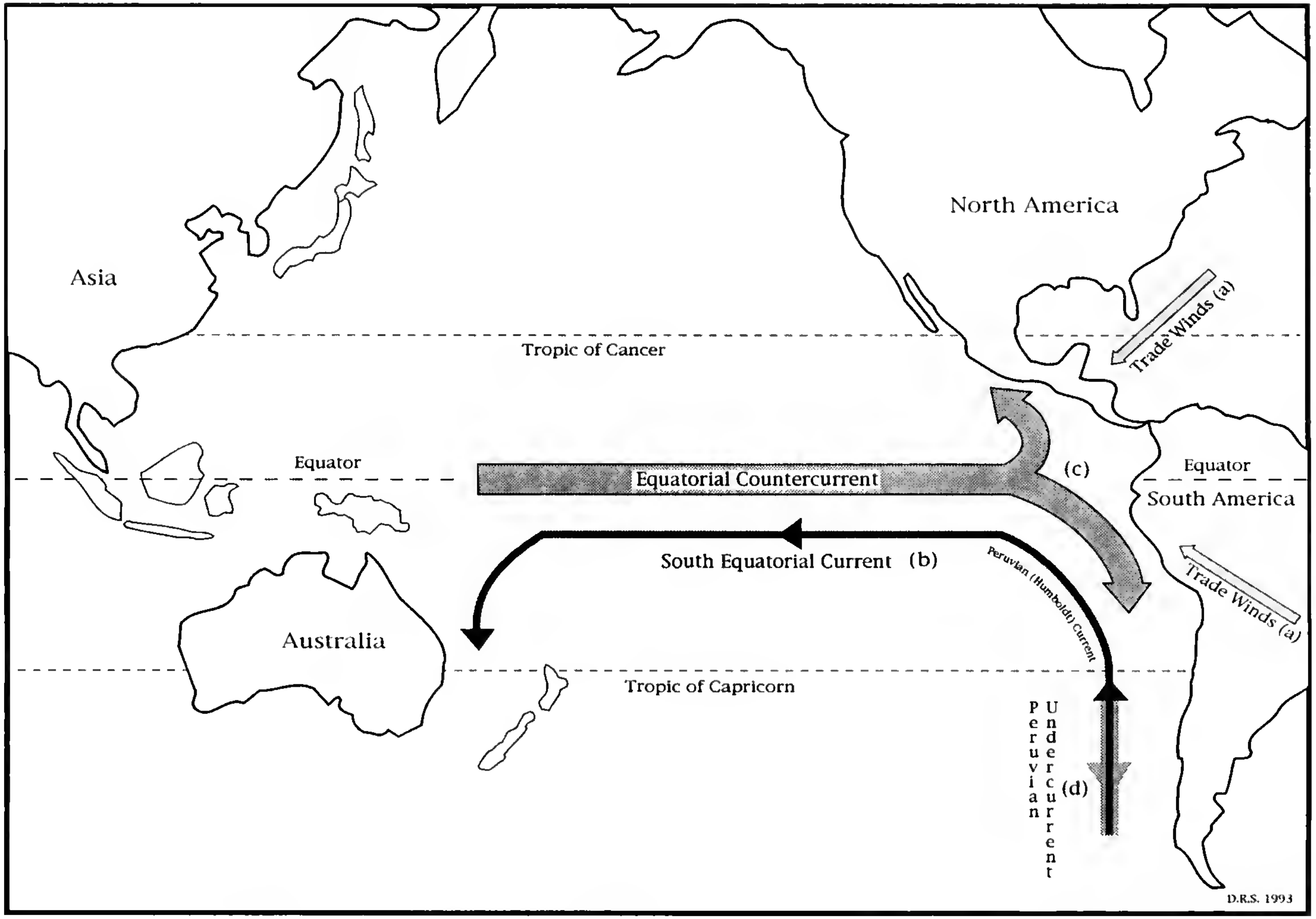


Figure 2-2: Ocean Currents during a Strong ENSO

Peru. For example, at Callao the SST increased 2°C per month for the last third of 1982 (Cane 1983). These extremely warm waters are carried south by the South Equatorial Current (Reverse Humboldt Current) when its flow reverses directions during an ENSO event as indicated by (c) in Figure 2-2.

After an actual Niño event, the anomalies slowly return to a normal condition, but SST anomalies lag behind their atmospheric counterparts. "This is consistent with the ocean's 'thermal inertia' and immense capacity for the storage of energy" (Ropelewski 1984:592). Nevertheless, after another slight warming beginning in the following December and continuing into the next year, the SST falls and often is cooler than normal, and the waters again resume their normal westerly flow.

The Peruvian (Humboldt) Current

Interacting with the El Niño Current, also known as the Equatorial Countercurrent, is the Peruvian (Humboldt) Current, i.e. South Equatorial Current, which is a layer of water driven by the wind northward toward the equator as indicated by (c) and (b) in Figure 2-2. Averaging 2.8°C cooler than other waters of the same latitude (Mason 1957), the Peruvian Current is an integral part of the weather system along the Peruvian coast because it cools the air and causes rain to fall off-shore, thus perpetuating the desert conditions on land. It also creates the persistent *garua* (fog and mist) along the coast during the winter in the Southern Hemisphere. As early as 1555 A.D., Augustin de Zarate (1965) noted the great coolness of the sea along the Peruvian coast.

However, it was the prolific author and great naturalist Alexander von Humboldt, after whom the current is named, who brought vital attention to the current in his early 19th century writings. He noted that the coastal waters of Peru were cooler than the air, and, therefore, the water must cool the air and not vice versa as was suggested earlier (Humboldt 1818; Merriman 1955).

Interacting with the Humboldt Current is the Peruvian Undercurrent, which flows just below the Humboldt Current along the coast southeastward toward the South Pole [see (d) in Figure 2-2]. This action supplies the cooler water and nutrients that upwell along the coast of central Peru (Smith 1983), which, in normal years (Table 2-2), is carried North and then to the West where it

Table 2-2: Classification of Oceanic-Atmospheric Conditions

El Niño Years		Normal Years			Anti-El Niño Years	
1925	1957	1927	1940	1956	1930	1964
1926	1965	1928	1942	1959	1937	1966
1932	1972	1929	1944	1969	1947	1967
1933	1973	1931	1945	1971	1948	1968
1939	1977	1934	1946	1975	1950	1970
1941	1978	1935	1949	1976	1951	1974
1943	1983	1936	1952	1981	1954	1979
1953		1938	1955	1982	1963	1980

(After Waylen and Caviedes 1985)

mixes with the warmer equatorial water. During the anti-El Niño years, the waters are even cooler than normal. However, during El Niño years, these processes reverse and anomalies transpire.

Southern Oscillation

Always accompanying a strong El Niño is the Southern Oscillation, which is "a coherent pattern of pressure, temperature, and rainfall fluctuations discovered and named by Sir Gilbert Walker more than a half-century ago" (Rassmusson and Wallace 1983:1195). The primary manifestation of the Southern Oscillation is an alternating change in atmospheric pressure at sea level between the southern Pacific subtropical high and the region of low pressure stretching from Africa to northern Australia. Other manifestations involve fluctuations in sea-surface temperatures in Africa, Indonesia, and northern Australia (Rassmusson and Wallace 1983).

The connection between an El Niño and the Southern Oscillation was not identified until the 1960s by Bjerknes, who discovered that a cycle exists where there is a positive feedback between the ocean and the atmosphere. Stronger equatorial easterlies increase upwelling in the West and, therefore, an east-west temperature contrast. This difference in temperature, in turn, increases the thermal driving of the atmosphere, thus creating stronger easterlies. The negative phase of this cycle is an El Niño Event.

The vacillating barometric pressures of the Southern Oscillation, the westerly winds, the warmer than normal SST, and

the ocean currents all interact helping to create the anomalies of an El Niño. The "driving force" behind these interactions is the ocean's circulation, which plays the role of a flywheel in the climate system, and this circulation is responsible for the extraordinary persistence of the atmospheric anomalies from month to month or even sometimes from season to season (Rassmusson and Wallace 1983).

Climatic Changes Associated with Strong El Niños

Exceptional Rainfall

One of the more unusual anomalies associated with an El Niño is the inordinate amounts of rainfall that occur along the normally hyperarid Peruvian Coast. "The result in the particular strong ENSO event of 1982-83 was a 40- to 60-fold increase in precipitation in the region" (Tapley and Waylen 1989:62). Some areas of northern Peru and Ecuador received rains 1,000 per cent greater than the 15-year monthly average (Arntz 1984:36). Although the 1972-73 El Niño was not as strong, nonetheless, increases of 15- to 30-fold in precipitation are recorded for that year.

An increase in maximum daily river runoff is, normally, a prime indicator for the amount of precipitation an area receives. All the rivers of the northern Peruvian coast exhibit a dramatic increase in runoff during strong El Niño perturbations (Table 2-3). In particular, the Piura River had a runoff 400 times its 30-year mean in January of 1983. It should be noted that precipitation patterns do vary somewhat from valley to valley and region to region (Waylen and Caviedes 1984), and large river discharges can

Table 2-3: Maximum Daily Runoff of Selected Rivers in Northern Peru, December, 1982 to May, 1983. Thirty Year Means measured in Cubic Meters per Second.

River	Dec.	Jan.	Feb.	Mar.	Apr.	May
Chira						
Max. Runoff	288.2	1197.2	1641.9	2282.0	2437.1	2375.4
30-Yr. Mean	36.6	86.6	220.4	309.3	323.5	134.8
Piura						
Max. Runoff	320.0	1314.6	1418.0	2428.4	2064.0	2473.0
30-Yr. Mean	0.5	3.6	59.8	108.2	89.7	29.9
Chicama						
Max. Runoff	66.2	112.3	81.8	900.0	600.0	400.2
30-Yr. Mean	8.9	33.4	66.6	101.7	78.2	29.7
Moche						
Max. Runoff	90.0	120.0	24.0	240.0	280.3	28.8
30-Yr. Mean	3.9	9.8	17.0	34.2	29.9	10.2
Virú						
Max. Runoff	14.4	80.0	9.0	70.3	120.0	10.0
30-Yr. Mean	1.3	4.3	10.1	14.8	10.0	4.0

(After Caviedes 1984)

be misleading unless accompanied by rainfall on the coast (Quinn et al. 1986). Nonetheless, when such massive runoffs occur, devastating concomitant floods usually follow.

This variation in precipitation can be seen in southern Peru where the 1993 El Niño precipitation is more than it was for 1991-92 event. The normally dry, lower Osmore River generally flows only briefly for one or two days in March because of highland precipitation (Figure 2-3; Manuel Pacheco, personal communication 1990). However, the river flowed in December, 1992, and again in January and March of 1993. The January flow was exceptionally strong and severely damaged some of the coastal highway which

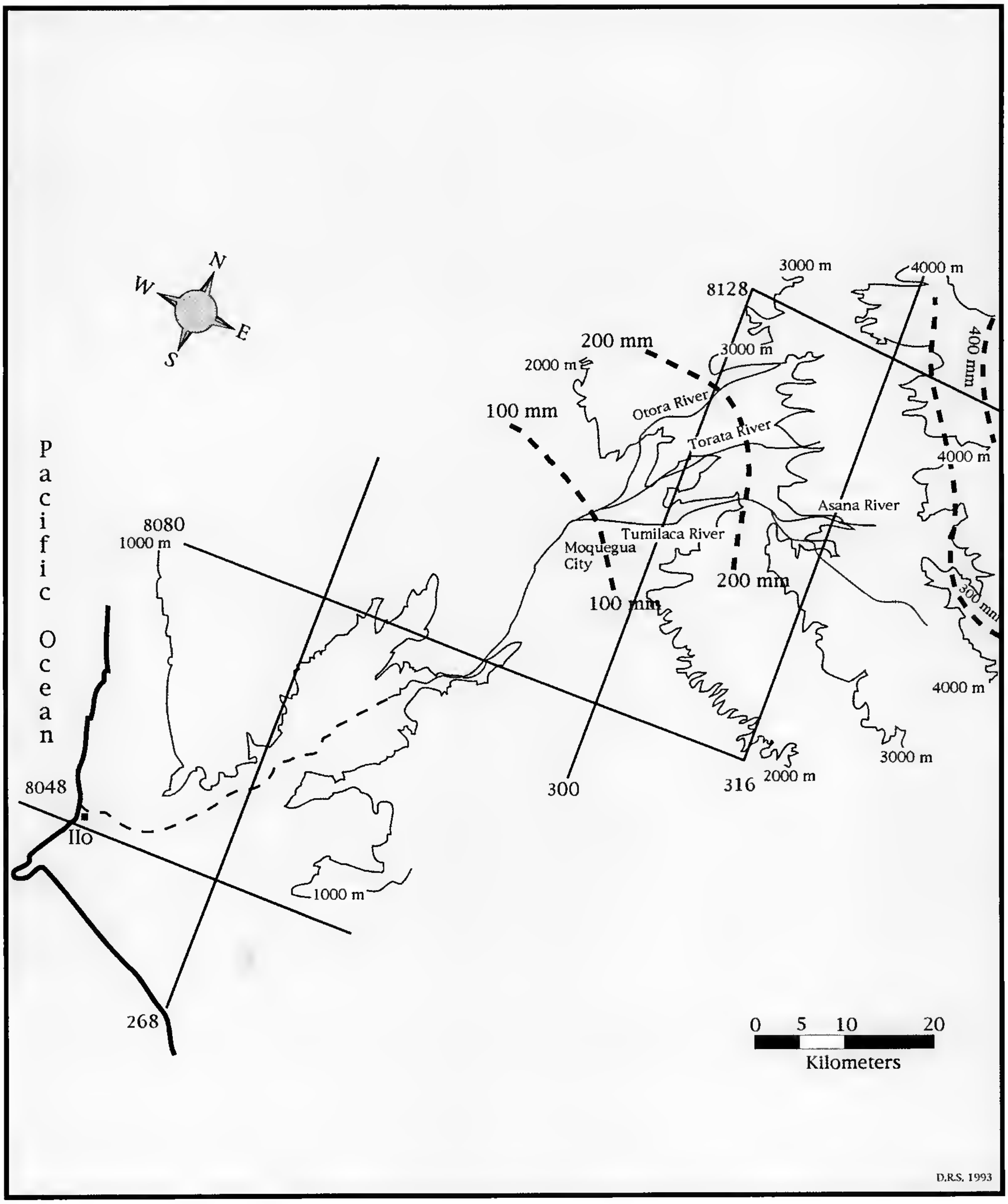


Figure 2-3: Average Precipitation--Osmore Drainage

runs through the town of Ilo in southern Peru (Sonja Guillen, personal communication 1993).

As Table 2-3 clearly shows, the daily run-off from each of these rivers swelled dramatically above the 30-year average during the 1982-83 El Niño. When rivers increase their flow as much as 3,600+ per cent above average in a span of a month of so, the impact on the surrounding terrain must be enormous. In light of the evidence, the massive coastal floods produced by such a torrent should have caused severe damage.

Drought Conditions

While much precipitation falls along the north coast of Peru during an El Niño, normally little rain falls along the southern coast and little snow or rains occurs in the high altitudes of the southern highlands. Currently, some of the most reliable data concerning both prehistoric and modern climatic conditions come from deep, glacial ice cores. Studies of the 1,500-year-record contained in the ice cores from the Quelccaya Glacier in southern Peru (Figure 2-1) demonstrate that a major dry season persisted from 920 to 1050 A.D. (Thompson et al. 1984). It was about this time that the ridged fields around Lake Titicaca were abandoned because of severe drought conditions (Thompson et al. 1984). The data also indicate approximately a 30 percent reduction in precipitation in the highlands during 1972-73 and 1982-83 events (Thompson et al. 1985). These were years with strong and very strong El Niños, respectively (Table 2-1). Even though the 1991-92 El Niño was not nearly as severe as the 1982-83 event, the drought conditions

were even more pronounced in some areas, especially in the valley surrounding Arequipa (Lorenza Carpe Diez, personal communication 1993).

These events seem to indicate that the pattern of copious rainfall along the coast during ENSOs, with a corresponding dearth of precipitation in the highlands, held true in prehistoric times as surely as it does in modern times. This pattern should not be too surprising since the modern climatic regime has remained fundamentally the same for approximately 4,500 years. According to recent evidence, there has been stochastic major flooding along the Peruvian littoral during this time (Rollins et al. 1986).

Correlations Between Volcanic Activity and El Niño Phenomena

Strong volcanic eruptions have been proposed by some as contributors to El Niño events--not so much as the singular cause of an El Niño, but as an adjunct to the atmospheric and oceanographic conditions that produce such an event. Handler (1984) has shown that a positive correlation exists between large magnitude, low latitude volcanic eruptions and the onset of El Niños (a negative correlation for high latitude volcanic eruptions exists). In 1600 A.D., Huayna Putina, in the southern highlands of Peru, erupted continually from February 19 until March 6, eclipsing the sunshine for seven days in Arequipa (Thompson et al. 1986). Therefore, if Handler is correct, then very possibly the disruption of the atmosphere by the Huayna Putina eruption could have contributed to the strong El Niño in 1607 A.D. (Table 2-1), whose flood deposits are found throughout the study area.

> There are other instances of El Niño occurrences during or following a year with major volcanic eruptions in tropical areas, the most recent being El Chichon during April, 1982, in Mexico. Notably the eruption of Krakatoa in 1883 was followed during the summer of 1884 by torrential rainfall in northern Peru, a typical manifestation of an El Niño event. Evidence supports that same association of El Niño phenomena during 1721, 1728, and 1804 with reported volcanic eruptions in the Pacific basin. In contrast, the occurrences of El Niño in 1911, 1925, and 1957 were independent of volcanism, but concurrent with large meteorological anomalies elsewhere (Caviedes 1984:290).

There seems to be a strong correlation between large magnitude volcanic eruptions and the El Niño phenomenon. The recent 1991-92 El Niño, rather than diminishing, is continuing into 1993, which is rather unusual because this is the first time in over four decades that an ENSO has persisted longer than one season (Quinn et al. 1979). It seems plausible that the 1991-92 Niño is continuing for another year because of the inordinate amount of volcanic tephra that was spewed into the atmosphere by the Pinatubo volcano in the Philippines in 1992.

Volcanic eruptions often do affect the climate, but the results seem to vary worldwide depending on the latitude of the volcano and the size of the eruption. The 1982-83 El Niño, the strongest event of the 20th century, was preceded by the eruption of Mt. St. Helens in 1980 and the eruption of El Chichon in 1982. Both of these events impacted the climate and may have affected the intensity of the 1982-83 event.

Although ENSOs can occur independently of volcanic eruptions, there is a correlation between large magnitude eruptions

and strong ENSOs. Therefore, it appears as if additional research concerning the link between climatic change and volcanic activities would be very useful. Fortunately, in the last decade, researchers have been investigating information, such as precipitation amounts, airborne dust, and volcanic ash, which are trapped within the glaciers of Iceland (Hammer et al. 1980), Peru, (Thompson at al. 1984, 1985, 1986, and 1988), and more recently in China ((Thompson et al. 1989; Ellen Mosley-Thompson, personal communication 1993).

Correlation between Global Warming and the Frequency of El Niños

There may also be a connection between global warming and its effects on the frequency and, perhaps, the magnitude of El Niños. Although early Spanish Colonial records may be lacking somewhat in detail, there seems to be a pattern of an increase in stronger events since the Industrial Revolution (Table 2-1). However, tree ring data from Chile and Argentina present contrary evidence that show no trend toward warming since the start of the Industrial Revolution (The Gainesville Sun [TGS], 31 May 1993). The mean temperature in this region has risen and fallen many times in the past few millennia. Nevertheless, ice core sampling from Greenland's ice sheet suggests that air pollution could lead to dramatic shifts in the climate over the next 100 years (The Tampa Tribune [TTT], 18 July 1993), which might affect the frequency of major ENSO anomalies. Innovative studies of fossil temperature changes retained in the earth, recovered by deep boreholes, show a general warming trend in a number of areas of the United States

and Alaska. Models predict that the warming trend should be most vigorous at the high latitudes. Nearly everywhere the warming has 20th century onset. Some areas evince temperatures that exceed global average, while others have cooled. Significant gaps in the borehole data exist for the Amazon Basin and other regions (Pollack and Chapman 1993:46-50). Currently, there are no data for the coast of Peru. Thus, the controversy continues, and it is only through such studies as this one that this connection may eventually be dismissed or established with certainty.

Effects of Strong El Niños

Introduction

When assessing the effects of a strong El Niño on a prehistoric culture with no written records, we must rely heavily on current data and draw conclusions from the impact of modern flood events on human populations and their infrastructures. Furthermore, we must assume that similar results could have occurred easily in prehistoric times as well. Only then can we test hypotheses against the geoarchaeological and archaeological records.

Climatic anomalies seem to be the norm for the years when a strong El Niño occurs. "During the summer of 1983 in the U.S., the climate was such that June was the 6th coldest on record, while August of that year was the hottest on record" (Ropelewski 1984:591). Europe and the British isles experienced an extremely dry and warm summer (Chen 1983), and July was the hottest ever in England where weather records have been kept for almost 350 years (Radcliffe 1983).

Flooding

The most immediate and dramatic consequence of a major El Niño is the catastrophic flooding that cripples the Peruvian littoral. These areas are normally inordinately dry since many of them receive only 45 mm of rainfall in a quarter of a century preceding an El Niño (Nials et al. 1979). "As might be expected, the pattern of annual flood size is dominated by elevation in normal and Anti-El Niño years (Table 2-2). However, in El Niño years, the pattern becomes more strongly influenced by latitude as the equatorial air masses related to the InterTropical Convergence Zone and the Equatorial Countercurrent move farther south" (Waylen and Caviedes 1986:151).

Devastating El Niño flooding is not exclusively a modern phenomenon because geoarchaeologists have determined that major flooding occurred in the Moche Valley as early as 500 B.C (Rollins et al. 1986). Another great flood--2 to 4 times greater than the 1925 flood--inundated, Chan Chan, the powerful capital of the Chimu Empire, in the early 12th century A.D. (Quinn et al. 1986). This flood disrupted the culture, and eventually the capital was abandoned.

About 1000-1100 A.D., the infamous "Chimu Flood" probably occurred (Nials et al. 1979). This monstrous flood may be the source of the legend about the great deluge which led to the demise of the king of Chot (Chotuna), called Fempellac (Donnan 1990). After he was tricked into sleeping with a demon, disguised as a beautiful woman, it rained continually for 30 days, which caused

much hunger in the area. The priests of the temple and other leaders became so angry because of Fempellac's offense against the gods that they bound his hands and feet and threw him into the sea ("lo hecharon en el profundo de el mar") (Cabello Valboa 1955:327-329 [1586]).

Early historical records from the 16th through the 18th centuries are often lacking in details concerning flooding since such an event was commonly viewed as a punishment for transgressions against a wrathful god (Quinn et al. 1986). Fortunately, 19th century observations were more scientific, and, thus, accurate records of the rainfall and the consequences of devastating flooding were kept.

The strong El Niño of 1891 was documented by a number of individuals in Peru, one of whom proposed a tentative theory concerning the inordinate amounts of rainfall. "The most reasonable explanations of these rains is that they have something to do with the *Corriente del Niño* or Reverse Humboldt Current" (Murphy 1926:35). "The last rains were in February, 1891, and they were certainly torrential . . . It seemed to come down in sheets, like a cloudburst, but was by no means local" (Murphy 1926:36). The flat plain at Talara in northern Peru was covered by three feet of water, and the resultant mess was like quicksand. As one author exclaimed, "In 1891, the situation was abnormal in the extreme" (Merriman 1955:70).

The flooding from the 1925 Niño was even more catastrophic. A third of the town of Huanchaco was totally obliterated as adobe homes were dissolved and washed away (Nials et al. 1979).

Hundreds of people died and thousands of homes were destroyed. Since "gutters and tin roofs were a luxury rather than a necessity," (Caviedes 1975:501) the incessant rains soaked the adobe walls, ceilings, and foundations to such an extent that they disintegrated.

Severe flooding has also destroyed much of Peru's patrimony. The impressive Huaca del Sol, which was already severely damaged in the early 1600s by the Spanish hydraulic mining efforts to retrieve precious metals from the tombs, experienced further damage during the 1925 El Niño. Yet, the damage was not nearly so much as that done by an ancient flood, ca. 500 A.D., which left a high-water mark a full 8 meters above the 1925 flood level (Nials et al. 1979). Evidence that both the Huacas del Sol and de la Luna were damaged, by this ancient flood, lies in the fact that the adobe bricks were saturated and "glued" together by the torrential rains and the flooding.

Located in the La Leche Valley, the Baton Grande-Poma archaeological Complex, with some three millennia of history, was not badly damaged by the 1925 event. Nevertheless, ca. 1100 A.D. a mammoth flood overwhelmed the citizens of the area forcing their relocation (Craig and Shimada 1986). Fortunately, these MegaNiños only happen at a rate of about two per millennium, but they are significantly larger and much more damaging than the 1982-83 event (Sandweiss 1986). Apparently the 14th century El Niño flood studied near Ilo is one of these rare events since it left widespread, deep deposits that would easily qualify it as a MegaNiño. It is also possible that this flood could have been

associated with previous, strong tectonic activity which would have sufficiently loosened materials for easy transport by flood waters.

There were a number of minor El Niños from the 1930s through the 1960s, but almost 50 years elapsed before the next major event. In 1972-73 the country of Peru was again pummeled by a strong El Niño. This time more people died and more property was damaged or destroyed, but this 1972-73 event merely foreshadowed the widespread destruction that would arrive in 1982-83. For months, the coastlines of Ecuador, Peru, and even Chile suffered relentless rainfall and flooding.

Disease and Pestilence

Flooding is an obvious and immediate consequence of a strong El Niño, but it is the disease and pestilence in the ensuing weeks and months following such an event that is often neglected by the news media in favor of the more sensational flooding sequences. It was reported, for example, that the floods immediately destroyed 12,500 homes and damaged 28,000 more in the Tumbes and Piura River valleys alone, during the 1982-83 event (Jackson 1984), but such massive flooding frequently causes many belated problems for humans that are often ignored.

Thus, although 800 people died in Peru during the 1982-83 El Niño (Thayer and Barber 1984), the survivors did not escape unscathed. In the north along the Rio Tumbes, "constant rains and humid atmospheric conditions compounded the picture of misery in which mosquito swarms and outbreaks of malaria, typhoid, and

skin diseases haunted the inhabitants of the valley throughout the summer, fall, and winter of 1983" (Caviedes 1984:277).

> At the peak of El Niño, rainfall, poor diet, and constant high humidity favored the spread of tuberculosis: a health report issued in June 1983 stated that 60 percent of the population of Chulucanas had contracted the disease . . . in the village of Canchaque . . . an epidemic of Uta, a leishmaniasis of the skin, spread, particularly among children, and caused terror among the rural population...[usually transmitted by biting flies, this disease produces single or multiple lesions with proliferating weeping ulcers and sloughing of skin] (Beck and Davies 1976).

Were this not enough, the valley was invaded by tropical bugs, among which was the *catigaza*, whose sting produced swelling, ulceration, and even paralysis of the affected limb, accompanied by fever (Caviedes 1984).

Health conditions were atrocious in many areas of Peru during 1983, but they were even worse in 1925. In addition to the millions of dragonflies, *caballitos del diablo,* there were millions more mosquitoes which carried the malaria virus. Besides the rampant malaria, dengue fever was a common malady. This infectious fever, which is usually epidemic, causes excruciating pain in the joints and muscles of its victims--hence, its nickname of "breakbone fever."

Because many railroad beds/bridges and roads were destroyed by flooding, dozens of towns and cities were isolated from food supplies. The poor diet contributed not only to

gastroenteritis, which claimed the lives of hundreds of children, but, also, to beriberi which caused the death of scores more because of the lack of vegetables (Murphy I926). Presented with the facts concerning the suffering following a modern event, one could easily imagine the misery and decimation that must have run amuck along the coast of southern Peru following the gargantuan 14th century El Niño event.

Impact on Coastal Agriculture

Humans are inextricably bound to the products of agriculture, and, when this valuable resource is disrupted by whatever means, we usually suffer. The 1925 flooding washed away, not only crops--i.e. rice, sugarcane, and cotton--but the none too plentiful top soil as well. To add to the misery of the winter winds and sand storms, hordes of crickets--*grillos*--feasted upon the scant vegetables (Murphy 1926). Burros and llamas replaced the railroad to carry the desperately needed foodstuffs slowly from the sierra to the coast.

In 1972-73, the rivers were so clogged with debris that they overflowed and completely drowned the riparian orchards and fields. In the Jequetepeque river basin, irrigation channels for the rice fields were destroyed (Caviedes 1975). Since the volumes of water associated with the 1982-83 event were so much more than other historical El Niños, the damage to agriculture and to related support facilities was even greater. Of course, crop loss was not restricted only to Peru. In two Ecuadorian provinces--Los Rios and

Machala--54,000 hectares of cropland were destroyed by flooding (Caviedes 1984).

Since the coast of Peru is a hyperarid desert, agriculture is totally dependent on the technology of irrigation. The rains of the 1982-83 El Niño either severely damaged or completely destroyed many irrigation canals. The Moche River washed away 500 meters of two main irrigation canals, while it filled some other sections of these open canals completely with sand. Also destroyed was almost a full kilometer of highway which is needed to transport the agricultural products to the markets and processing facilities (Feldman 1983).

Again, many of the El Niño related problems, such as damage to agricultural infrastructure and diseases that plague modern Peru following a major perturbation, should hold true for prehistoric times as well. Also, the impact of the 14th century A.D. megaflood must have been even greater owing to the lack of adequate technology and a sufficient labor force with which to recover from such grievous disasters.

Impact on Highland Agriculture

While the coast suffers from devastating rains and floods during a strong El Niño, the highlands suffer from catastrophic drought. In the southern highlands around Lake Titicaca, in 1983, 70 percent of the major staple crop, potatoes, was destroyed. This crop failure was quite serious because the indigenous population mainly survives the long winter months by eating freeze-dried potatoes--*Chuño*--which can be easily stored for the entire winter

season. Unfortunately, because of the severe drought and the extreme food shortage, even the seed potatoes for next year's planting had to be eaten (Jackson 1984). Even though there was some precipitation in the highlands around Lake Titicaca, "the scattered rainfall of February and March 1983 was insufficient to grow potatoes, quinoa, maize, and alfalfa during the peak of summer" (Caviedes 1984:288).

Famine is normally alleviated by kin groups sharing food with each other. This native "disaster relief" is usually sufficient to cope with the frequent droughts and subsequent low crop yields, but in 1983 the situation was so dire that this traditional "risk management" system was inadequate. To compound an already grievous situation, some highland people were incapable of helping their kin since entire villages, along with all the potentially helpful relatives, were completely buried by mud slides. A full one-third of the remaining villages were also badly affected by this particular ENSO event (Feldman 1983).

Domesticated Animals

Not only humans endure great suffering during strong ENSO events, but domesticated animals, mainly camelids, such as the *Llama* and *Alpaca*, also do not fare well during these times. During both the 1925 (Murphy 1926) and 1982-83 events (Jackson 1984), as pasturage became scarce because of the drought, the sheep and camelids in the highlands began to starve. At the other extreme along the north coast, especially near Trujillo, vast tracts of

valuable pasture were totally obliterated by flash floods, further impacting domesticated grazing animals.

The most seriously drought-affected areas were the highlands of southern Peru and Bolivia. By the end of April, 1983, the drought had spread from the Titicaca basin to the entire altiplano and had wreaked hardship among traditional cattle and llama herders. As was the case during previous El Niño-related droughts (1891, 1941-42, 1957, and 1972), the level of Lake Titicaca dropped to record lows. The herds of cattle and llama become so thin that social problems resulted for many poor peasant families because they were accused of not properly caring for their livestock. Unable to maintain the weakened animals, some peasants sold them at extremely low prices, while other families pushed to the limits of need and despair, even sold their own children to wealthier families (Caviedes 1984:288-289).

Marine Life

In normal years, the main upwelling centers of the Pacific Ocean, extending as far South as the Paracas Peninsula, coincide with the greatest carbon-producing areas and with the richest anchovy grounds along the Peruvian coast. An El Niño triggers a devastating crisis in the ecosystem. The upwelling of the cool water weakens, and the less salty and oxygen-poor warm tropical waters overlap the cold waters of the Peru Current, resulting in a sizable decrease in phytoplankton and zooplankton, which feed the anchoveta (Caviedes 1975).

A strong El Niño event severely disrupts the ocean's production of both chlorophyll and phytoplankton by as much as 75 percent. The larval anchovy feed on phytoplankton, but, as fate would have it, the zooplankton do also. So the failing food supply is now even more diminished for the young fish and, as a result of the competing zooplankton, millions of the larval anchovy do not survive (Walsh et al. 1980). As if this destruction were not enough misfortune, even those anchovy which do survive decrease in absolute growth and reproductive success (Barber and Chavez 1983).

Even the weak El Niño of 1975 caused an 80 percent reduction in the productivity of nutrients, and this production occurred in a narrower zone than in normal years (Cowles et al. 1977). "When the warm surface water invades the Peruvian littoral, the sensitive anchovy dives down some twenty meters to colder waters or migrates southward . . . " (Caviedes 1975:498).

"The major El Niño, in 1972, combined with overfishing, almost wiped out the vast school of anchoveta (*Engraulis Ringens*) that had propelled Peru into first place among fishing nations (with a catch greater than the combined total of both North and Central Americas)" (Feldman 1983:17). Before the 1972 event, Peru accounted for one-fifth of the world's total fish production (Caviedes 1975). This loss of the anchoveta catch, of course, affected the fishmeal production and, consequently, the price of beef since cattle eat the fish meal as a protein source. Without the fish meal, cattle owners had to turn to more costly soybeans as a substitute.

The anchovies died off or were so severely depleted after 1977 that pilchard (a member of the herring family) replaced anchovy as the mainstay of the fishing industry. These small fish can survive in warmer waters between 23°C and 25°C, while anchovy cannot. Unfortunately, the horse mackerel, which preys on both pilchard and anchovy, also prefers these same warm waters. Therefore, the number of the fish available to commercial fishermen steadily declined (Caviedes 1984). For example, the anchovy catch declined from 1.7 million tons in 1982 to 100,000 tons in 1983 (Arntz and Tarazana 1990). Of all the marine life it is the middle of the normal food web that is disrupted the most by the anomalies of an El Niño (Arntz and Tarazana 1990:333).

Yet another threat to the fishing industry in Peru, caused by El Niños, is called a red tide, which has caused the death of countless fish along the Peruvian coast. "Red tides are spectacular dinoflagellate blooms that occur in oceans and often lead to mass mortality of marine fishes and invertebrates" (Krebs 1978:540). Because of the warm weather anomaly, when the water temperature, salinity and/or nutrients are in certain proportions, the marine protozoans (dinoflagellates) rapidly increase. The Biological Oxygen Demand (BOD) required by aquatic bacteria to decompose the accumulated metabolic waste from the billions of protozoans is such that there is not enough oxygen for the fish to survive (Owen 1980). In March of 1990, 24 tons of fish washed ashore at Chimbote (Francisco Mamani, personal communication 1990). Although it is uncertain at this time, it appears that a red tide may have caused their demise.

Murphy (1926) relates that, in 1891, during the day the sea was covered with blood-like patches many acres wide. The final effect of this freak of nature was that so many fish and other marine life died that the subsequent hydrogen sulfide produced actually blackened the white paint on the ships in the Callao Harbor (Merriman 1955). In 1925 another red-tide appeared. "As testimony to the loss of life, the gruesome phenomenon is a harbinger of death appropriately known as *El Pintor* (the painter) (Nials et al. 1979:7). The loss of human and animal life in total numbers, as a consequence of a strong El Niño event, seems small when one assesses the total impact on marine life. Yet, understandably, this loss may not be of great significance to anyone--except, perhaps, the fishermen.

Guano Birds

Many of the guano producing sea birds eat pilchard, anchovy, and other smaller fish when they are driven to the surface by larger marine predators. During an ENSO event, these larger predators move from the extraordinarily warm waters to cooler waters elsewhere. When this happens, some birds migrate to other areas, but most birds actually starve to death because the smaller fish are not readily available at the surface. For example, there are normally 300,000 birds on Christmas Island; by the Spring of 1983, there were none inhabiting the island (Thayer and Barber 1984). Those birds which stay closer to the coast fare somewhat better, but thousands still die for want of sufficient food (Barber and Chavez 1984).

The guano birds are quite important economically to the people of Peru since these *guanay*--cormorants, gannets, and pelicans--produce a valuable fertilizer (Caviedes 1984). Prior to the 1925 event, the guano bird population was estimated at 30 million. The strong 1925, and 1972-73 El Niños have reduced their numbers to 7.5 million (Nials et al. 1979). Murphy (1926) describes the scene following the 1925 El Niño, by saying, "By the end of January sick and dead guano birds began to be numerous in northern Peru, and the *peste* (plague) spread rapidly southward until countless thousands of carcasses lined the whole shoreline of the country" (1926:32). Surely it will take years for nature to rectify the decimation of the millions of birds along the Peruvian littoral caused by the El Niños of this century.

Economic Impact

It is almost unbelievable that something as innocuous as an influx of warm water could so drastically disrupt the ecosystem along the western coast of South America, but the evidence speaks for itself. During the 1982-83 El Niño, the worldwide combined loss of human life from floods, polluted water supplies, and drought has been estimated at 10,000 or more deaths. Property damage has been estimated at $10 billion (Dillon 1985:6-7). In addition to the death of 800 humans in Peru, the total destruction from the 1983 event alone is estimated at over 3 billion dollars (Thayer and Barber 1984). Included in this staggering figure is the loss of hundreds of millions of dollars for the Peruvian fishing industry, which has for years been a major source of income for the country.

The fishing industry first felt a financial crunch in the 1920s when the local fisheries along the coast failed as the common schooling species, i.e. anchovy, etc., died or departed (Murphy 1926).

The 1972-73 El Niño's disruption in the ecosystem started an immutable chain reaction of events for the 128 fishmeal factories then in existence. Burdened by debts, low productivity, maintenance costs, and wages, sixty-five small fishing plants, most locally owned, faced bankruptcy, and the owners were willing to sell their plants to the Peruvian government for whatever was offered. The remaining plants had financial backing because they were owned by foreign countries or by 10 Peruvian magnates who could absorb the losses and continue operations at a reduced level. Finally, to preserve the fishing industry, on May 7, 1973, it was nationalized in an effort to control the growth of the industry, the welfare of the fishermen, and the marketing of the sea products (Caviedes 1975). Following the 1982-83 event, the fishing situation became so desperate that the entire fishing fleet continually tried a variety of new techniques to catch whatever it could (Barber and Chavez 1983).

Positive Consequences of an El Niño Event

Lomas

Fortunately, there are some positive consequences of an El Niño. After encountering so much suffering, destruction, and death, any small glimpse of beauty is a welcome respite. Ironically, while the human disaster continued, a vast area of the desert in northern Peru was in "full bloom with green shrubs everywhere" (Jackson

1984:33). In some places, wet fog drifts inland from the sea, and when there is enough fog, a seasonal flora develops in what are called *Lomas*--these areas are not a continuous band, but more like an "island archipelago" of verdant patches of vegetation (Dillon 1985).

"Current tabulation of the entire lomas flora shows it to contain ca. 1,000 species of angiosperms and ferns" (Dillon and Rundel 1990). Included in these various families, genera, and species are rare plants, which are being carefully studied in an effort to understand their origins and the formation of these idyllic "islands" (Pare 1984). It is believed that the composition of the plants and flowers reflect past climatic and geologic events (Dillon 1985) and, thus, can be useful in modern attempts to reconstruct and to understand these ancient events.

For years, people have been observing and recording the beauty of the desert when it awakens from its long, barren sleep. It has been suggested that Pizarro's march through the Piura area, as he and his men trekked toward Cuzco in 1532, "was possible only because he chanced to land upon the desert shores during one of the rare "*años de abundancia* " or years of abundant water and vegetation" (Murphy 1926:54). In 1891, during another one of the "years of abundance," when the rains occurred, one person noted, "the desert soil is soaked by the heavy downpour, and within a few weeks the whole country is covered by abundant pasture" (Murphy 1926:35). Although this pasture is ephemeral, when it dries it affords goats a natural hay for a year or so. Often seasonal lakes and ponds are created by these monsoon-like rains and the plant

life proliferates, attracting flocks of ducks from as far away as the Guayaquil region. In some places, for the first time in forty years, flowering plants reached the coast (Murphy 1926)

During the rain of 1972, as well as of 1925, in many places the buried grass seed germinated providing ample grass which more than met the grazing needs of the ranchers in northern Peru. In fact, this new-found abundance encouraged some local ranchers to import many thousands of feeder cattle and breeding stock. Goat herds were seen roaming around various areas taking advantage of the unusual fresh vegetation during the fall and winter months of 1972 (Caviedes 1975).

In 1983, there was a particularly rich bloom in the *Lomas* along the coast of Peru and as far south as Chile. Typically the unusual outburst by the dormant vegetation appears some two or three months after the maximum rainfall. The Peruvian government has even designated one area as a national park--*Lomas de Lachay*--which is located about two hours drive north of Lima (Caviedes 1984). Even in the far south of Peru, there is lush pasture in the normally desert-like Sama river valley during such events, and the local herders bring their cattle into the valley to enjoy this rare serendipity (Francisco Mamani, personal communication 1990).

Applying Modern El Niño Data to Prehistoric Settings

The Peruvian landscape is one of the most dynamic in the New World, if not in the entire world. Peruvian history is rife with examples of major seismic events, including the most devastating

historical earthquake in the Western Hemisphere, i.e. May 31, 1970 (Silgado 1978; Webb and Fernández Baca de Valdez 1991). Further proof is provided by the impressive number of El Niños events that have re-sculpted the Peruvian countryside during the last 450 years (Quinn et al. 1986). Both earthquakes and strong El Niños have a great impact on humanity, and it seems reasonable that "phenomena that alter subsistence systems and disrupt means of agricultural production are likely candidates for triggering change or ethnic movement during the course of Andean civilizations" (Moseley 1987:7).

Using an ethnohistorical approach, one should be able to use the available modern data concerning the impact of El Niño flooding on modern humans and to apply these data to prehistoric populations. We can compare the modern accounts (e.g. Murphy 1925; Caviedes 1975, 1984, among others) to the early historical accounts of floods in Peru to extrapolate and to determine the validity of these written records concerning the consequences of these events for humans. Vivid descriptions by Alcocer (1987 [1582]) of the 1578 A.D. catastrophic rains and flooding that severely affected the north coast of Peru are but one example of the early works which can be used to infer what the impact of the earlier 14^{th} century A.D. Miraflores Flood might have been for the Chiribaya Culture of extreme southern Peru.

Since the occupants of the coastal quebradas studied in this dissertation were dependent upon a highly developed, sophisticated irrigated agricultural system, there is little doubt that, following the destruction of this system by the 14^{th} century El

Niño, the indigenous population, which had occupied the area for almost 400 years, would have been severely reduced by starvation and disease. Without an adequate workforce to rebuild, repair, and maintain the agricultural subsistence base, the culture could not have regained its pre-flood eminence. Therefore, it would have lost its hegemony, and it would have been in a very vulnerable position with regards to invasion or simply an in-migration by a non-resident culture. (For a detailed discussion of the impact of an early El Niño on the Chiribaya Culture refer to Chapter 8).

As previously noted, archaeologists must, by necessity, draw upon modern flood data when interpreting the effects of El Niños on prehistoric populations. Flooding of cultivated land, along with diminished sea resources, as a result of a particularly intense El Niño, results in drastic food shortages today. The prehistoric consequences must have been even more disastrous (Jackson and Stocker 1982:22). Currently, there is no contrary evidence that the devastation and the diseases associated with contemporary events should not apply equally to a prehistoric population. In fact, because of the lack of modern medicine and technology, the disruption of an autochthonous prehistoric society should be even greater than that suffered by a modern society.

CHAPTER 3

ARCHAEOLOGICAL BACKGROUND

Introduction

As with all other countries, the history of Peru is a fascinating story of the gradual development of unique cultures throughout many centuries. This history is divided in various ways, but it is almost universally agreed that the most significant milestones of cultural development that fall within the scope of this study can be demarcated by the titles of "Initial Period" (IP), "Early Intermediate Period" (EIP), and "Late Intermediate Period" (LIP). Therefore, it is important to examine each of these periods in turn to understand the vital role that irrigated agriculture played at each step along the Peruvian journey through time.

Initial Period

A number of cultural changes occurred during this period. Early coastal sites were abandoned; monumental architecture shifted inland; and there was an increased consumption of cultivated plants (Moseley and Deeds 1982). At the beginning of the Initial Period, around 1800 B.C., agriculture began to spread into new habitats, which included coastal valleys. "This must imply some mastery of irrigation techniques, since without these, agriculture would scarcely have been possible in such arid

surroundings" (Fung 1988:82). Orlove (1985) suggests that maize was a relatively new domesticate that was preceded by potatoes (ca. 2000 B.C.), peanuts (ca. 2500 B.C.) and the "industrial cultigens" cotton and gourd (ca. 3000 B.C.) during the Preceramic Period (:46). Some, however, would argue that maize has been cultivated as early as 4000 B.C. in Colombia (Bray et al. 1987).

At this same time, population increased and the mountain and coastal settlements began to crystallize into "poles" of influence (Moseley 1992). Spectacular developments, such as mound building, free-standing architecture, and weaving during this period are largely attributable to the technology of irrigation agriculture, which provided people with more leisure time (Pozorski and Pozorski 1987:125). Also, pottery, associated with storage, cooking, and, perhaps even more importantly, with the brewing of *chicha* (a native corn beer used as an integral part of religious ceremonies) appears on the central coast of Peru around 1800 B.C.

Early Horizon

Building upon the incipient agricultural base created during the Initial Period, early Peruvians increased their dependence upon maize agriculture during the Early Horizon. In some of the coastal valleys, irrigated agriculture was undoubtedly expanded. In the highlands, the use of ridged fields and *cochas* (sunken fields) increased agricultural yields and extended the farming season (Moseley 1992). New cultigens, such as manioc (*Manihot esculenta*), tree tomatoes (*Solanum muricatum*; *Cyphomandra splendens*), Jiquima (*Pachyrryzus tuberosus*), and probably sweet potatoes (*Ipomoea batatas*) were added to the ever-growing inventory of

domestic plants. However, the Peruvians still placed an emphasis on marine resources and further supplemented their diet with hunting and gathering. As a consequence of the diversification in subsistence resources and an improved diet, population increased considerably and nearly all of the coastal and highland valleys were settled (Lumbreras 1969).

Religious centers, with new art and iconography dictated by the Chavin cult, appeared in the highlands and along the Peruvian coast from the Moche River to the Mala River valley. With the new art came changes in textile production, such as textile painting, dying of camelid hair, and the heddle loom. Pottery styles now included stirrup-spouted bottles, stamped decorations, and the neckless olla with motifs stressing super-natural beings, especially the fanged anthropomorphic "staff god". Using such innovations, the spread of corporate art and iconography probably helped precipitate a coalescence of a multitude of distinctive local and regional cultures into what is commonly referred to as the Chavin Horizon, a significant, but short-live phenomenon (Burger 1988). Metallurgy also experienced meaningful modifications with the introduction of three dimensional forms produced by soldering pre-shaped metal sheets, silver/gold alloying, and repoussé decorations. Accompanying these changes, were marked social stratification and an increase in the demand for exotic goods exchanged between ecologically complementary zones (Burger 1988).

Early Intermediate Period

A change in the settlement patterns occurs with the residential centers now outnumbering the ceremonial centers (Moseley 1992). There were other significant developments during this period, which included an even greater increase in population accompanied by construction of large irrigation systems on the desert coast. Hints of a possible increase in warfare or a greater need for defense are suggested by the many fortifications built at this time. Nucleated settlements, with populations as large as 10,000, were present at Moche, Nazca, and Pukara, and an estimated two million people inhabited the coastal areas (Lanning 1967).

Middle Horizon

This was a time of severe droughts which adversely affected both agriculture and the great complex cultures which depended so heavily upon it. A great drought lasted from 562-594 A.D. (Thompson et al. 1988), that greatly curtailed agriculture since evidence indicates that the precipitation was 30 percent less than normal. This drought was probably a contributing factor in great ethnic movements and conflict of the Middle Horizon (Moseley 1992).

There were not only severe droughts during the Middle Horizon, but devastating floods as well. In the Moche Valley, flooding stripped away many meters of precious soil and severely damaged fields and irrigation canals, forcing the abandonment of the Mochica capital, Huaca del Sol (Moseley 1992). A new capital

was built at Cerro Galindo, which was located at the valley neck near the irrigation canal intake—perhaps to protect them from outsiders (Bawden 1985).

New irrigation techniques were introduced, and the Huari (Wari) were among the first to irrigate slopes using short, low canals to farm limited areas (Moseley 1992). At Huari, high water sources fed long, primary canals which, in turn, fed into secondary canals that watered the extensive terraces. The Huari used this new technique to develop the unfarmed slopes in the Moquegua Valley, 60 km upvalley from the study area (Goldstein 1989; Figure 3-1; Table 3-1).

Table 3-1: Middle Horizon Cultures

Time	N. Coast	Cen. Coast	S. Coast	Moquegua	Titicaca
1000 A.D.	Sican	Chancay	Ica	Tumilaca	Tiwanaku
900 A.D.	Sican		Ica	Tumilaca	Tiwanaku
800 A.D.	Sican		Ica	ChenChen	Tiwanaku
700 A.D.	Sican	Huari	Ica	ChenChen	Tiwanaku
600 A.D.	Moche	Huari		Omo	Tiwanaku

(After Moseley 1992)

<u>Late Intermediate Period</u>

The Late Intermediate Period (L.I.P) began in about 1000 A.D., approximately concurrent with the decline of the Tiwanaku Empire, and lasted until the rise of the Inca Empire, ca. 1476 A.D., at the beginning of the Late Horizon (Table 3-2; after Rowe 1962;

Figure 3-1: Moquegua in Southern Peru

Lumbreras 1974). The capitals at both Huari and Tiwanaku had already been abandoned toward the end of the Middle Horizon (Rowe 1963). Therefore, this period was a time of change because "the decline of the Wari (Huari) Empire disrupted the unity that had been imposed on the Central Andes and permitted the resurgence of local or regional political organizations" (Lumbreras 1974:179).

The Late Intermediate Period was similar to the Early Intermediate Period because it was also a time with increasing population, small political units sometimes associated with larger confederations, and warfare (Lumbreras 1969). Some coastal areas

Table 3-2: Periods and Horizons of Peruvian Prehistory

Periods/Horizons	Time Scale	Also Known as
Late Horizon	1476-1532 A.D.	Imperialist
Late Inter. Period	1000-1476 A.D.	Urbanist
Middle Horizon	600-1000 A.D.	Expansionist
Early Inter. Period	200 B.C.-600 A.D.	Experimental
Early Horizon	900-200 B.C.	Cultist
Initial Period	1800-900 B.C.	Formative
Preceramic	2500-1800 B.C.	Archaic
Lithic	8000-2500 B.C.	Hunter/Gatherer

were depopulated and, within a few centuries, small regional states appeared in various parts of the former Huari Empire (Patterson

1973:101). It was a time of marked local cultural diversity and relative isolation, contrasting with the Middle Horizon which had been dominated by the two rather large, interactive empires of Huari and Tiwanaku. According to Inca tradition, there was "a situation of extreme political fractionation in the sierra at the beginning of the Inca Dynasty" (Rowe 1963:16).

With the exception of perhaps Chan Chan and Pachacamac, most of the cities were abandoned by the end of the Middle Horizon, and the prevailing pattern of settlement became one of small, urban centers with dispersed dwellings. Perhaps this new pattern was a reaction against large cities which exerted too much control over all the inhabitants--much like the rural population revolting against the late Roman cities. This backlash occurred in areas where city traditions were old, but not on the north coast of Peru (Rowe 1963:19-20). This Middle Horizon settlement pattern would remain unchanged until the Incas placed people in nucleated settlements where they could better watch and control the people's activities (Patterson 1973:69).

The only regional state in existence during the L.I.P. was Chimor, the great Chimu Empire that extended for a 1,000 km along the northern and central coasts of Peru (Conrad 1981; Moore, 1991; Figure 3-2). In other areas of Peru, there were polities that developed a social organization based on small towns and villages; however, they did not achieve large scale political integration, like that of Chimor. These polities included the following: the Chancay on the Central Coast; the Lake Kingdoms, Colla and Lupaqa, around Lake Titicaca; Pisco, Ica, and Nazca Valleys of the south coast ruled

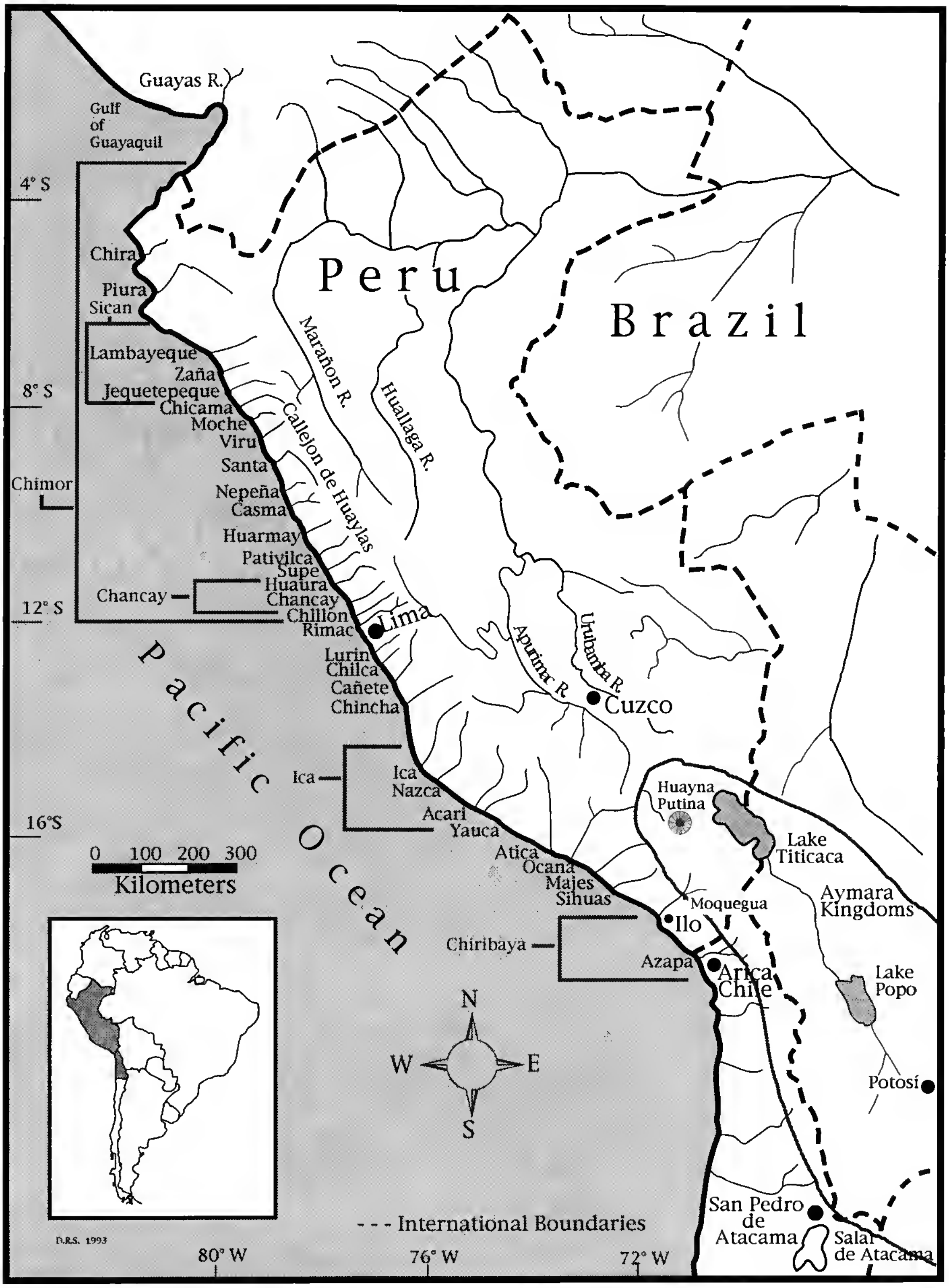


Figure 3-2: Cultures of The Late Intermediate Period

by the "Lord of Chincha"; and the Chiribaya on the extreme southern coast in the department of Moquegua (Table 3-3).

Table 3-3: Late Intermediate Period Cultures

Time	N. Coast	Cen. Coast	S. Coast	Moquegua	Titicaca
1476 A.D.	Inca	Inca	Inca	Inca	Aymara
1400 A.D.	Chimu	Chancay	Ica	Estuquiña	Kingdoms
1300 A.D.	Chimu	Chancay	Ica	Chiribaya	Aymara
1200 A.D.	Chimu	Chancay	Ica	Chiribaya	Kingdoms
1100 A.D.	Chimu	Chancay	Ica	Chiribaya	Aymara
1000 A.D.	Chimu	Chancay	Ica	Chiribaya	Kingdoms

(After Moseley 1992)

Cultural History of the Ilo Region

Lithic Period

The Ilo coast has a lengthy human history which extends back into the Lithic (Hunter/Gatherer) Period. Located 7.5 km South of the city of Ilo and dating to ca. 8000 B.C., the Ring Site is the oldest littoral site in Peru (Sandweiss et al. 1989; Table 3-4). This maritime site consists of an almost perfect 26 m-wide circle of discarded mollusks shells (Richardson et al. 1990). In addition to over one hundred stone tools, 7 different types of bone implements, including a bone harpoon were recovered at the Ring Site. Faunal

Table 3-4: Ilo Time Chart

Time Frame	Lower Ilo Valley	Ilo Coast	Moquegua	Highlands	Arica, Chile	Natural Events
Initial Period						
900 B.C.		Wawakiki/ Carrizal				
1000 B.C.		Wawakiki/ Carrizal				
1100 B.C.		Wawakiki/ Carrizal				
1200 B.C.		Wawakiki/ Carrizal				
1300 B.C.		Wawakiki/ Carrizal				
1400 B.C.		Wawakiki/ Carrizal				
1500 B.C.		Wawakiki/ Carrizal				
1600 B.C.		Carrizal				
1700 B.C.		Carrizal/ K-4				
1800 B.C.		Carrizal/ K-4				
Preceramic Period						
1800 B.C.		Carrizal/ K-4			Chinchorros	
1900 B.C.		Carrizal/ K-4			Chinchorros	
2000 B.C.		Carrizal/ K-4			Chinchorros	
2100 B.C.		Carrizal/ K-4			Chinchorros	
2300 B.C.		Carrizal/ K-4			Chinchorros	
2500 B.C.		Carrizal/ K-4			Chinchorros	
Lithic Period						
2500 B.C.					Chinchorros	
3000 B.C.		Villa del Mar		Toquepala Asana	Chinchorros	
4000 B.C.		Villa del Mar		Toquepala Asana	Chinchorros	
5000 B.C.		Villa del Mar		Toquepala Asana	Chinchorros	
7000 B.C.		Ring Site		Toquepala Asana		
8000 B.C.		Ring Site		Asana		
9000 B.C.				Asana		

analysis shows that the diet was based almost exclusively on marine resources, such as gastropods, bivalves, and chitons.

In the highlands above Moquegua, hunter/gatherers of the Lithic Period occupied natural rock shelters and caves. People used laurel-leaf shaped stone projectile points to hunt camelids and other small animals of the puna (Lumbreras 1969). The Toquepala Cave contains wall paintings of humans hunting camelids (Table 3-4). Situated at about 2000 m.s.l., this cave was occupied, mostly during the wet period from October to April, for many years, beginning ca. 9500 B.C. (Moseley 1992).

Another wet season site, dating from about 9600 B.C. to 3600 B.C., is the open-air settlement of Asana located at 3450 m on the highland puna above Moquegua. The inhabitants of Asana exploited the local fauna all year, and, during the dry season, humans and animals alike depended on the ground seeps—*Bofedales*—as freshwater sources (Aldenderfer 1989). This site contains one of the earliest ceremonial structures in all of Peru. Measuring almost 12 m by 9 m, this rectangular ceremonial complex has a wide clay floor, altars constructed of rock and clay, and walls made of mud and clay (Aldenderfer 1990).

Preceramic Period

Preceramic Period sites along the Ilo coastline include K-4, which dates to as early as 4620 B.P. +/- 90 (BETA) (Wise et al. 1994), with occupation continuing into the Initial Period (Table 3-4). This site consists of a large shell midden and domestic terraces, which are located less than 100 m from the Pacific Ocean. Early

sites at the Carrizal Quebrada date from about this same time period, i.e. 4690 B.P. +/- 100 years (BETA) (Wise 1990). Human occupation at the Carrizal Quebrada is almost continual until modern times (Bawden 1990) probably because of the freshwater springs and the fact that this quebrada has easy access to the marine resources, which were exploited by the early residents, just as they still are today.

Another important coastal site dating to this period is *Villa del Mar*, first investigated in 1986 because of a double burial uncovered during a construction project (Torres et al. 1990). Several Chinchorros-like burials were excavated here in 1990 by Dr. Karen Wise. The Chinchorros were fisherfolk who occupied the northern Chilean coast from ca. 5000 B.C. and used a wide variety of fishing tackle including nets, harpoons, and fishhooks made of shell or cactus thorns. The Chinchorros people are perhaps most noted for their elaborate mummification techniques, which involved the preservation of the viscera and also the bracing of the vertebral column and the long bones of the deceased with cane supports (Allison et al. 1984).

Initial Period

The preceramic sites, which were located along the coast adjacent to the springs at the Carrizal Quebrada, were still occupied during this period, with the inhabitants clearly exploiting all of the micro-ecological zones. Marine resources were augmented by terrestrial hunting and gathering (Bawden 1990), but there could have been some early agricultural fields which were subsequently

destroyed by the later Chiribaya occupation of this quebrada. This subsistence strategy was the beginning of an adaptive system which would be incorporated into the later ceramic periods and would endure until the Colonial Spanish Period.

The primitive Carrizal pottery sequence, which includes the neckless olla, is related to other early undecorated ceramics, such as Faldas del Morro from Chile and the Huaracane style from an early agricultural culture in the upper Moquegua Valley (Feldman 1990). The Huaracane pottery, which also includes a neckless olla style, belongs to a pottery horizon which begins around 850 B.C. towards the end of the Initial Period and lasts until 300 A.D. of the Early Intermediate Period. This same type of pottery is also found in the Bolivian highlands during the middle Wankarani phase and at Chiripa (Feldman 1990; Table 3-5).

Early Horizon

The Neckless Olla (*Olla sin cuello*) ceramic tradition begins as early as ca. 800 B.C. in the Ilo area (Table 3-5). The style of this large, wide-mouthed cooking vessel persisted considerably longer than a millennia. By about 200 B.C., the neckless olla was produced at the Early Horizon sites at the Carrizal Quebrada (Bawden 1989, 1990). The importance of this domestic vessel is clearly established by the fact that 80% of the pottery sherds found at Carrizal were of this type. Neckless olla also accounted for the largest ceramic component at the Ilo Valley sites of El Algodonal and Loreto Viejo (Owen 1992a.).

Table 3-5: Ilo Time Chart

Time Frame	Lower Ilo Valley	Ilo Coast	Moquegua	Highlands	Arica, Chile	Natural Events
Early Intermediate Period						
600 A.D.	Neckless Olla	Neckless Olla	Omo	Huari Tiwanaku ua	Cabuza	
500 A.D.	Neckless Olla	Neckless Olla	Omo	Hauri Tiwanaku IV	Cabuza	
400 A.D.	Neckless Olla	Neckless Olla	Omo	Tiwanaku IV		
300 A.D.	Neckless Olla	Neckless Olla	Huaracane			
200 A.D.	Neckless Olla	Neckless Olla	Huaracane			
100 A.D.	Neckless Olla	Neckless Olla	Huaracane			
0 A.D./B.C.	Neckless Olla	Neckless Olla	Huaracane			
100 B.C.	Neckless Olla	Neckless Olla	Huaracane	Wankarani Chiripa	Faldas del Morro	
200 B.C.	Neckless Olla	Neckless Olla	Huaracane	Wankarani Chiripa	Faldas del Morro	
Early Horizon						
200 B.C.	Neckless Olla	Neckless Olla	Huaracane	Wankarani Chiripa	Faldas del Morro	
300 B.C.	Neckless Olla		Huaracane	Wankarani Chiripa		
400 B.C.	Neckless Olla		Huaracane	Wankarani Chiripa		
500 B.C.	Neckless Olla			Wankarani Chiripa		
600 B.C.	Neckless Olla			Wankarani Chiripa		
700 B.C.	Neckless Olla			Wankarani Chiripa		
800 B.C.	Neckless Olla			Wankarani Chiripa		
900 B.C.						

Early Intermediate Period

Although located 300 km from the Tiwanaku heartland, there was a strong Tiwanaku presence in the upper valley around the city

of Moquegua. As a result of the studies conducted since 1983 by archaeologists of the Programa Contisuyu, the local Tiwanaku sequence is now well-understood. Based on the data from excavations at domestic sites and cemeteries, the local sequence is now divided into the following phases. The earliest occupation is called Omo and corresponds to the "Classic" Tiwanaku IV phase (Table 3-5). Ceramics from the Omo phase are characterized by banded keros, angular bowls, and incense burners with 2 wings. The strong affect of the Tiwanaku State on Omo pottery is indicated by the painted decorations rendered in black, orange, and white on red, which is a common tradition for all of the pottery from Tiwanaku (Goldstein 1990).

Middle Horizon

The Omo Phase of the Tiwanaku influence in the Moquegua Valley continued into the early Middle Horizon, but it was replaced, ca. 700 A.D., by the Chen Chen phase which continued until about 950 A.D. (Goldstein 1989; Table 3-6). At about the same time that the Chen Chen phase ends in the upper Moquegua valley, the Ilo/Tumilaca occupation begins in the lower Ilo Valley (see below). The ceramics from the Chen Chen Phase (Tiwanaku V) also reflect the form and decoration of the Tiwanakan State. The common decorated pottery forms are keros without bands or a single band, large cups in the form of a half-kero, and jars with only one handle. Other common utilitarian artifacts include decorated wooden spoons. A new style of kero with a human profile appears for the first time late in this phase. Stylized flamingos and parrots painted

on the vessels were among the most common motifs. Although the neckless olla sites in the Ilo Valley had long been abandoned where the influx of highland influence, nonetheless, the neckless olla tradition is still well-represented in the ceramic record of the Middle Horizon.

It was toward the end of the Middle Horizon when the lengthy Osmore Canal was probably begun. The question of who truly constructed this masterful irrigation system still remains a matter of contention. At least one author, Owen (1992a), believes that because of the proximity of their settlements to the canal, the Ilo/Tumilaca, rather than the Chiribaya, built the canal. It must be remembered, however, that the Ilo/Tumilaca designation used by Owen corresponds almost exactly to what Jessup (1990, 1991) calls the El Algarrobal Phase of the Chiribaya Culture. Therefore, it is quite possible that even if the Chiribaya did not actually begin the construction of the valley irrigation system, they at least expanded it to its farthest extent.

Late Intermediate Period

At the beginning of the Late Intermediate Period, around 1000 A.D., sites in the middle Moquegua Valley were abandoned and the upper valley and the coast were settled. Owen (1992b) suggests that this abandonment of the upper valley sites restored more irrigation water to the lower Ilo Valley and, therefore, could have provided the impetus for the expansion of agricultural land. The Ilo/Tumilaca/Cabuza (I/T/C) tradition persists until about 1250

A.D. when it is rather abruptly replaced by the more populous Chiribaya Culture (Owen 1992a). Since the number of Ilo/Tumilaca

Table 3-6: Ilo Time Chart

Time Frame	Lower Ilo Valley (1)	Ilo Valley and Coast (2)	Moquegua (3)	Highlands	Arica, Chile	Natural Events
Colonial Period						
1607 A.D.						Chuza Flood
1604 A.D.						Earthquake Tsunami
1600 A.D.						H. P. Eruption
1550 A.D.	Spanish	Spanish	Spanish	Spanish		
1532 A.D.						
Late Horizon						
1532 A.D.	Inca	Inca	Inca	Inca		
1476 A.D.	Estuquiña/ Inca	Estuquiña/ Inca	Estuquiña/ Inca	Inca		
Late Intermediate Period						
1476 A.D.	Estuquiña/Inca	Neckless Olla	Estuquiña		Gentilar	
1400 A.D.	Burro Flaco San Geronimo	Neckless Olla	Estuquiña		Gentilar	
1300 A.D.	San Geronimo/ Yaral(1)	Neckless Olla	Estuquiña		San Miguel	1350 A.D. Miraflores Flood
1200 A.D.	Yaral (1)	Ilo/Cabuza (2) Neckless Olla	Estuquiña		San Miguel	
1100 A.D.	Yaral (1)Algarrobal	Ilo/Cabuza (2) Neckless Olla	Tumilaca (3)		San Miguel	Chimu Flood
1000 A.D.	Algarrobal (1)	Ilo/Tumilaca(2) Neckless Olla	Tumilaca (3)		Maitas/ Cabuza	
Note: Local culture/tradition classifications according to (1) David Jessup (1991); (2) Bruce Owen (1992a); and (3) Paul Goldstein (1989, 1990).						
Middle Horizon						
1000 A.D.	Ilo/Tumilaca(2)	Neckless Olla	Chen Chen	Tiwanaku V	Cabuza	
900 A.D.		Neckless Olla	Chen Chen	Tiwanaku V	Cabuza	
800 A.D.		Neckless Olla	Chen Chen	Tiwanaku V	Cabuza	
700 A.D.		Neckless Olla	Chen Chen Huari	Huari	Cabuza	
600 A.D.		Neckless Olla	Omo Huari	Huari Tiwanaku IV	Cabuza	

sites had decreased by 50% by the beginning of the Ilo/Cabuza phase, there is a strong possibility that the I/T/C simply could not adequately compete with the Chiribaya Culture which reached its zenith at about 1200 A.D. during the Yaral Phase (Jessup 1991; Table 3-6). Although the Yaral Phase ceramics were identified from the grave accompaniments at the middle valley site of La Yaral, this pottery style is also found at the lower valley sites of Chiribaya Alta and Chiribaya Baja, and at the coastal site of San Geronimo (Jessup 1990).

It is presently unclear as to the origin of the Chiribaya people. It has been proposed that they may have emigrated from the highlands into the Ilo Valley, or they may have developed independently from an earlier Preceramic population or the Ilo/Tumilaca people (Jessup 1990, Owen 1992b.). There is some indication that there may have been some Chiribaya influence along the extreme northern Chilean coast or vice-versa since the Chilean San Miguel and Gentilar ceramics (very similar to the Chiribaya styles) were found co-existing with the Chiribaya ceramics at the site of Chiribaya Baja (Jessup 1987, 1990; Table 3-6). Currently DNA studies are being conducted on some of the human remains recovered from the cemetery at Chiribaya Baja in the Ilo Valley, and, perhaps in the near future, the results of these investigations may provide us with a definitive answer as to the origin of these Chiribaya people.

The last phase of the Tiwanaku presence in Moquegua is the Tumilaca, which actually occurs after the decline of the Tiwanakan State. The manufacture and the decoration of the Tumilaca

ceramics indicate a gradual loss of contact with the altiplano. For example, the paste now contains more sand; the color yellow is used instead of red; and the keros are very large. Further, white dots, similar to the common Chiribaya decoration, are used, suggesting a trend toward the Chiribaya style of ceramics (Goldstein 1990).

The Late Intermediate Period was probably a time of hostility because structures at the Tumilaca site include a wall and a perimeter trench which are strong indications of a defensive posture (Goldstein 1990). With the exception of the large Chiribaya Alta site, no other locations in the lower Ilo Valley have defensive moats or walls. Almost all of the major settlements by the Late Intermediate Period were fortified, and in the Moquegua Valley, all independent irrigation areas and their villages had walls and dry moats (Moseley 1992). Fortified sites of this period were probably created to protect the natural resources of the region and the irrigated agricultural fields (Moseley 1990).

Another prominent fortified site is the Huari settlement located on the top of Cerro Baul, a truncated cone of stone which rises an impressive 400 m above the valley floor. The almost impregnable fortress was likely a necessity since the Huari colony had intruded into the Tiwanaku presence already firmly ensconced in the Moquegua area. Centuries later, the Cerro Baul fortress would prove to be vulnerable when it fell to the invading Incan army after a 50 days' siege (de la Vega 1989).

Following the end of the Tiwanaku occupation in the Moquegua Valley, the Estuquiña Phase begins around 1100 A.D. With natural escarpments providing defense on the east and south

sides, the "type site" of Estuquiña was occupied from about 1100 A.D. to 1500 A.D. Late in the period, the Estuquiña were contemporaneous with the Gentilar of Chile and the Inca (Lozada 1987). However, there is no evidence indicating that there was habitation at Estuquiña after the Spanish Conquest (Rice et al. 1990). Estuquiña pots and bowls show few significant characteristics other than opposing prominences around the upper edges of the vessels. Other common Estuquiña ceramics are double-handled ollas, jars with one handle, and jars modeled in the shape of a boot or a duck (Rice et al. 1990; Williams et al. 1990).

About 1100 A.D., the Chiribaya established an upvalley enclave at La Yaral, which was occupied for about 200 years. In the lower Ilo Valley and in the coastal quebradas, agrarian expansion by the Chiribaya reached its height around 1000 A.D. (Moseley 1993), and then began to contract slowly because of changing environmental conditions, and, by the time of the Inca occupation of the Ilo area, most of the irrigated terrace systems had long since been abandoned.

Intensification and Development of Irrigated Agriculture

Introduction

Early great civilizations, such as Mesopotamia, Egypt, and Mexico, all reached their zeniths in arid regions under irrigation (Kosok 1942; Mason 1957; Wittfogel 1957; Heiser 1973), and Peru was certainly no exception. "One of the major areas of prehistoric civilization in the New World is the stark desert landscape of coastal Peru" (Jackson and Stocker 1982:12). "At a time when our

ancestors in northern Europe were still utter savages, clothed only in skins, and living by hunting and fishing, settled agricultural communities must have existed in the Peruvian region" (Cook 1916:474). All the major states and the independent polities, that were extant during the preceding Middle Horizon, were highly dependent upon intensive agriculture (Table 3-3). During the Late Intermediate Period, the Chimu State and the smaller polities used, as did their predecessors, some type of creative and highly productive agricultural technology--irrigation canals (*asequias*), terracing (*andenes*), raised fields (*camellones*), or sunken fields (*cochas--lagunilla* in Spanish) (Guillet 1992).

There are two theories, the Drainage Theory and the Floodwater Theory, concerning the origin of canal irrigation. As with some other popular theories they do not apply to Peru in general. The Drainage Theory states that canal irrigation developed from the technology used to drain and direct excess water from productive land. The technology was simple and minimized downcutting, sedimentation, meandering and overflowing of streams (Doolittle 1990:138-189). This theory might be applied by some to northern Peru because of the presence of raised fields in the Casma Valley. However, this technology of constructing raised fields does not appear in the archaeological record of the north coast until almost 1,000 years after the development of canal irrigation. It seems more likely that valley necks and inland locations were the setting for the new technology and economy of irrigated agriculture (Moseley 1975b) because these inland areas

required shorter lead-off canals and, therefore, less labor to build and maintain (Moseley and Deeds 1982).

The Floodwater Theory states that planters first farmed in arid areas on alluvial deposits which were periodically inundated by floodwaters from upland rain. Subsurface moisture would remain for some time after the flow subsided, thereby allowing some cultivation (Doolittle 1990:140). This theory could apply to areas such as the Nile River Valley which, until the building of the Aswan High Dam, had practiced such agricultural methods. It might also be applicable to the Moche Valley where a floodplain exists (Moseley and Day 1982). However, once again, canal irrigation in Peru probably did not advance as a result of floodwater agriculture because, of the 57 river valleys and drainages in Peru, only a few have permanent rivers, which could supply sufficient spring flood waters.

Sunken fields were late additions to the prehistoric agricultural repertoire. They generally occur in a topographically low area lying very near the coast, but they have been found as much as a kilometer inland from the littoral in the Chicama, Moche, and Pisco Valleys among others (Smith 1985:519). Sunken fields are known by different names depending on the geographical location and the time period in Peru. They are called *Pukios* or *wachaques* on the north coast, *mahamaes* in the Chilca Valley, and are referred to as *hoyas* by most of the early chroniclers (Smith 1985:603). According to Cobo, *Hoyas* were used by the native Peruvians to increase farmland (Mateos Tomo II, 1956:92). Large depressions, up to 100 m wide, were dug into the earth below the

water table, and crops were planted along the slopes of the sunken fields (Cabello Valboa [1586] 1955; Donnan and Mackey 1978; Moseley and Feldman 1984; Smith 1985).

It is only in recent times that modern engineering has been able to surpass the irrigation projects of the PreHispanic Peruvian agrarian societies (Horkheimer 1990).

> The Chimu were probably the greatest Pre-Hispanic agriculturalists in coastal Peru. Only within the past decades has the amount of irrigated land in the Chicama and Moche Valleys equaled the area cultivated by the Chimu, and this has required the extensive use of pumps and cement-lined canals (Kus 1972:193).

For example, North/Northwest of Chan Chan, the Chimu had irrigated 1,600 hectares in one area alone (Kus 1972:199). During the early Late Intermediate Period more canals were built and extended into previously uncultivated plains (Parsons and Hastings 1988:198). These large irrigated agricultural works, occupying suitable alluvial plains, were all state controlled by this time (Kus 1980). Rural administrative centers represented the "state presence" even in the non-metropolitan areas of the Moche Valley and maintained control over land, water, and labor resources (Keatinge 1974:67). Labor was often made available as a tax payment to the state (Conrad 1981). At its height, Chan Chan controlled, at least, 66 percent of the irrigated coast lands (Moseley and Deeds 1982:25).

Most early eyewitness accounts mention, with some degree of awe, the vast terraced and irrigated agricultural systems which

they encountered throughout Peru (Cieza de Leon [1552], 1971; Cobo [1653], 1979, 1990; Sarmiento de Gamboa [1572], 1967; Guaman Poma de Ayala,[1613], 1980; Pizarro [1571], 1972; Sancho [1550], 1917; 1972; de la Vega 1989). Cieza [1552] notes "all the land of the valleys, where the sand does not reach, up to the wooded areas, is one of the most fertile and abundant lands of the world..." (1971:25). With just a little work, using irrigation water from the rivers, it was possible to cultivate abundant crops (Cieza 1971). This type of agriculture is particularly important in the sierra because "irrigation permits the cultivation of a broader range of crops at higher altitudes than would be possible with natural rainfall alone" (Mitchell 1977:38).

Since the narrow, coastal plain of Peru is one of the world's driest deserts (Brush 1977; Lettau and Lettau 1978), where agriculture is extremely difficult and virtually impossible without irrigation, Cobo [1653] noted that "not a twentieth of this large stretch of land is productive" (1979:4). According to Squier, "The Sahara is a 'thing of beauty' and Arizona 'a joy forever' compared to the coast of Peru" (1877:25). "It never rains, thunders, snows, nor hails in all this coast, which is a matter worthy of admiration. {However,} a little distance from the coast it rains and snows terribly" (Acosta [1604] Vol. I, 1970:164). "Rain does not fall until it reaches the cooler elevations of the Andes at altitudes above 2,500 m" (Pozorski and Pozorski 1987:1). This natural aridity accounts for the fact that about 22 percent of the cultivable land today in Peru is located on the coast, while the sierra has almost 62

percent of the arable land and produces the majority of the food for modern Peru (Claverlas et al. 1983).

Unfortunately, the total area under cultivation today in the Andes is from 30% to 80% less than it was the during the Pre-Hispanic periods, depending on the region (Wright 1963; Moseley and Deeds 1982; Masson 1986; Denevan 1987; Clement and Moseley 1991). Perhaps part of the reason for this disparity is the fact, as one author explains, that the use of contemporary terraces is sometime underreported (Mitchell 1985). The Titicaca region has the largest ridged field system in the world (Kolata 1991:101), where ridged fields have been used since 2500-3000 B.C. (Erickson 1987:374). Yet in the Titicaca Basin alone, there are 200,000 ha (Hectares) of abandoned terraces, 90,000 ha of abandoned or plowed up *qochas* (*cochas*) sunken fields, and 80,000 ha of abandoned or destroyed ridged (raised) fields (Browman 1987:175).

Truly, the Titicaca area has a tremendous amount of potential for food production because, during the Tiwanaku Empire, just the 3,500 hectare raised field agricultural system, at Pampa Koani could have fed an estimated 60,000-100,000 people annually and still have produced a food surplus (Kolata, 1987:40). At just 75% usage of the ridged fields, mono-cropping could support a minimum of 285,000 people (Kolata 1991:110). Tiwanaku developed its mighty empire partially based on the ridged field system surrounding Lake Titicaca (Kolata 1983, 1986) and at one time dominated highland Bolivia and the coastal portions of southern Peru and northern Chile (Orlove 1985).

It is a lamentable fact that this once highly productive agricultural system has been abandoned for centuries (Kolata 1983). Luckily, experiments in the reactivation of some of these ancient raised fields at Puno and Pampa Koani, on the south side of Lake Titicaca, have been conducted in recent years resulting in crop yields that are 2-4 times the average yield from other agricultural fields (Erickson 1987, 1988; Kolata and Ortloff 1989; Kolata 1991).

Although ridged fields are found throughout the Tropics, they are relatively rare along the arid coast of South America. Yet in the Casma Valley, it is estimated that the abandoned ridged field system once encompassed as much as 3,100 hectares (Moore 1985:265; Pozorski et al. 1983). "The Casma Valley is unique in having ridged fields, rather than sunken gardens, which are the most common feature on the high water table regions of the coast" (Pozorski et al. 1983:407).

Fossil ridged field systems also exist in Bolivia, as well. This area, in general, offers important archaeological data about various impressive projects of PreHispanic engineering. For example, in addition to the ridged fields, there are canals, water wells/reservoirs, and roadways. Some of the canals and roadways are still in use today, though some have been repaired through time (Erickson 1980). Perhaps some of the most spectacular vestiges of ancient ridged fields are found in northern Colombia (Smith et. al 1968; Broadbent 1987), and, also, in Ecuador (Parsons and Shleman 1987), where maize cultivation, on ridged fields, dates to 500 B.C. (Pearsall 1987:287).

Water Management

Today water rights are owned and regulated by the state water administration (*Administración de Aguas*) (Hatch 1976; Guillet 1992), rather than being totally controlled by the *ayllu,* or the community, as had been the case for millennia. However, the various irrigated sections have elected water judges (*Regidores*), who hold weekly meetings at which "water shares" are granted to users (Guillet 1987c). Permission for use of water is granted in the descending order of domestic usage, animal husbandry, agriculture, hydroelectric power, industry, and mining (Guillet 1992). Farmers are advised of what day their particular branch canal (*rama*) will be provided with water (Hatch 1976), and they must determine their specific needs according to the availability of water (Farrington 1985). It is a common practice for a single household to control a branch canal, while many households control a main canal (Brush and Guillet 1985). This type of water management is a far cry from Pre-Hispanic days when, even during dire times, water was doled out to everyone, regardless of rank or social status (de la Vega, 1989).

Development of Agriculture

Why did humans abandon nomadic hunting and gathering or sedentary fishing lifestyles in favor of a new sedentary agricultural life style? Boserup (1965) proposes that the development of agriculture was the result of population pressure (see also Patterson 1973) which necessitated the creation of a more prolific system of food production (see Carneiro 1970). It is generally agreed that

population density is a crucial factor for giving impetus to the intensification of agriculture because it is usually the number of people residing in a particular area that determines the necessary level of food production. By about 1 A.D., population increase and social demand in the Moche Valley possibly caused an expansion of arable land (Farrington 1985:648). Based on her studies, Boserup suggests that labor-intensive irrigation allowed for a more intensive system of land use, "multi-cropping," which would increase the amount of arable land and raise crop yields, thereby increasing the carrying capacity of the land (1965:39). However, others maintain that multi-cropping "appears to have been practiced only sparingly in the prehistoric world" because crop varieties which allow a traditional farmer to produce more than one crop per year have only been recently developed (Farrington 1980:288).

Sauer (1952) thought that agriculture on the desert coast of South America derived from elsewhere because the environment demanded the advanced skills of irrigation. He believed that the northwest coast of South America was the likeliest place to find the origins of agriculture because of its abundant aquatic and riparian life and fertile land. This region provided a sheltered basin with the "proper balance of self-containedness and outside contact" (1952:42). He may have been in error with these statements, but he was, however, slightly *avant garde* when he stated, "sedentary fishing people perhaps commenced the cultivation of plants and became the first domesticators of plants and animals" (1952:103; see also Moseley 1975a, 1992; Moseley and Feldman 1988).

Social Change Associated with Agriculture

With the advent of irrigation agriculture, a number important social changes occurred. Agriculture allowed for a stable, improved diet which in turn created a greater concentration of people, transforming primitive societies into complex social/political structures (Kosok 1942). These structures included a more efficient social organization and a concomitant expanding power over people and, especially, the control of labor.

According to Wittfogel (1957), ancient states arose and gained despotic control of dense populations because of the control of water in arid regions. In many hydraulic societies, the state retained control over the private property owners by keeping them disorganized and impotent (1957:3-4). Irrigation farming always requires more physical labor than does dry farming because controlling large amounts of water through channelizing requires some type of direct authority that subjugates many people (1957:17). Therefore, "effective management of irrigation works requires an organizational web that covers the whole or, at least, the dynamic core of a country's population" (1957:27).

Carneiro (1970), who advocates environmental circumscription as the cause for the origin of the state, sees the many, short, narrow valleys of the Peruvian coast as a classic example of what he champions. Each valley is "backed by mountains, fronted by the sea, and flanked on either side by desert as dry as any in the world" (1970:735). As the size of autonomous villages grew, the population would fission and move to other usable land. When there was no more available land, agriculture

had to intensify, and previously unusable land was brought under cultivation by means of terracing and irrigation (1970:735). With increasing population pressure, conflicts for control ensued, and the conquered people usually would be politically subjugated.

Wittfogel's theory and, perhaps, also, Carneiro's theory might be true for some coastal areas of the Peru, but, in general, they may not be true for other areas of Peru. According to Guillet (1990) there was no despotism on the Central Coast of Peru, even though there were centralized hydraulic systems with bureaucracies. Further, in the Peruvian highlands, there were both small-scale village or inter-village irrigation systems (1990:7) where water resources, i.e. rivers, springs, and seeps, as well as land resources, were collectively owned and operated by an *ayllu*--a corporate, endogamous, hierarchical descent group (Brush 1977; Moseley 1992; Denevan 1987). There is no evidence that a more elaborate system beyond the traditional *ayllu* was necessary to effectively manage highland agricultural systems (Erickson 1987).

"Recent literature in Andean archaeology and ethnohistory asserts the dominance of local kin groups in the organization of agricultural production rather than supracommunity state authority" (Kolata 1991:99). Water is distributed according to custom by the people who assembled at the distribution points, not according to some despotic control (Mitchell 1977:50, 57). There is further criticism of these theories because there is a lack of studies of contemporary highland communities in Peru and there has been too much focus on coastal irrigated agriculture (Mitchell 1977).

In southern Peru, there were independent coastal populations, such as the Ica and Chiribaya, which maintained control over their water resources and never reached a social organization level beyond that of a polity. Rowe (1963) explains that in the Ica Valley, large cities came first, and only later were there major irrigation canals. He says that it is very difficult to argue for any relationship between irrigation and the development of cities (1963:20). Lanning (1967) states that we cannot say that irrigation led to the centralization of authority, but rather that once authority was centralized, then it became possible to build and maintain irrigation systems. Thus, irrigation was a product of civilization, not a cause of it (1967:181-182).

Whether the society is classified as a state or polity, the social organization and control of a society dependent on either a small- or large-scale irrigation system remains basically the same. There exists a controlling body that directs the construction of terraces, fields, and irrigation canals, regulates the distribution of water, sets production quotas, and determines the planting and harvests cycles (Harris 1975).

Now that the stage was set for large-scale irrigation projects, agriculture expanded into heretofore undeveloped and unoccupied areas, such as the hyperarid coast and the steep Andean slopes (Moseley 1992). Not only the vast tracts of abandoned agricultural works, but also the impressive number of earthen and stone mounds and pyramids remaining on the Peruvian landscape are all mute testimonies to the amount of human labor that was released from other pursuits by the accession of agriculture.

Motivating Factors for the Development of Agriculture

What were the some of the motivating factors which influenced the development of agriculture? One possible explanation was that geological uplift had drained the productive shallow bays and lagoons that had been relied upon for marine resources. Practicing incipient agriculture by growing gourd and cotton needed to manufacture fishing floats and netting, preceramic people had laid the ground work for agriculture. Further, preceramic people were "preadapted" for irrigation agriculture because they had centrally coordinated labor (Patterson 1988), such as had been used to build the impressive *Huaca de los Idolos* at Aspero (Feldman 1977:15-16; Moseley and Day 1982).

Browman (1987) cogently argues that the shift to agriculture allowed farmers to utilize various techniques to reduce production risks. To enhance the land's carrying capacity, land and water management systems, such as ridged or raised fields, terrace systems, and irrigation canals were developed by prehistoric Peruvians. Irrigation agriculture may date to 1000 B.C. in some places in Peru, (Farrington, 1985), or, perhaps, as early as 1500 B.C. in the Moche Valley (Moseley 1978).

Although desiring the credit for using divine knowledge from their creator god, *Viracocha*, to develop irrigated agriculture (Cobo 1990), the Incas had merely perfected a technology that had been developed at least 2 millennia before their rise to power (Guillet 1987). Using *Mit'a* labor, a form of taxation, the Incas built irrigation canals and agricultural terraces and channelized rivers,

mostly during the late 1400s (1450-1475) (Schaedel 1978:290; Cook 1916). "Terrace building in the Andean valleys under the Incas was primarily for expansion of maize cultivation wherever possible in association with irrigation" (Keeley 1985:548). The Inca improved upon irrigated agricultural technology bringing the art of terracing to its pinnacle by expanding agriculture to encompass an astounding 1,000,000 ha of terraced land (Donkin 1979).

Canal irrigation appears in the archaeological record of Peru at about the same time as do agricultural terraces, in 500 B.C. (Donkin 1979). Amazingly, a few of the Pre-Inca irrigation canals have been in continuous use for 1,500 years in the Moche Valley (Horkheimer 1990). Although these canals are among some of the earliest in the New World, certain canals in Mexico have been dated to about 800 B.C. (Doolittle 1990).

Advantages of Agricultural Terracing

There is reason to believe that terracing began sometime around 500 B.C. (Initial Period) and continued into Inca Times (Late Horizon). Agricultural terracing was such an impressive feature of the Peruvian landscape that "the Conquistadors named the Andes for their greatest monument to human endeavor--the *andenes* . . . "(Moseley 1983b:190). Sancho [1550] noted, perhaps with some exaggeration, "All the mountain fields are made in the guise of stairways of stone . . . "(1917:149; see also Cook 1916). "Terracing is an ancient practice continued {today} mainly by traditional farmers because it is labor intensive and not conducive to mechanization" (Denevan 1987:1).

Agricultural terracing represents an attempt to overcome inherent problems associated with cultivating slopes. Rugged terrain requires slope modification to avoid excessive run-off and erosion (Brush 1977). Terracing slows run-off allowing the water to soak in while, at the same time, the excess water flows downslope at a much slower rate of speed, which prevents soil erosion by rain on the steep inclines (Denevan 1987). Depending on the slope angle, terrace width varied from 1-1.5 m and terrace length from 15-60 m (Cobo 1990:212).

In addition, the level surfaces of terraces slow the water, suspending fine particles, and allowing the heavier materials to precipitate out. The finer particles are then passed on to a lower terrace, which, in many cases, helps enrich the thin, nitrogen-poor Andean soils (Orlove 1977:27). Also, excess water drains off through the fissures in the stone retaining walls preventing root damage from water logging. At the same time, ample water soaks into the soil preventing root damage from desiccation and water loss from evaporation. This type of water management also helps conserve the fragile fertility of the mountain dirt (Horkheimer 1990) because the natural soil cover in most parts of Peru is very thin and poor in nutrients, and, therefore, it is easily exhausted and dries quickly (Donkin 1979).

<u>Use of Fertilizers</u>

For centuries the Andean farmers have used fertilizers to augment their nutrient poor soils. The two most important prehistoric fertilizers were guano (Cobo 1599; Acosta 1604;

Garcilaso 1609; Mason 1957; Lanning 1967; Donkin 1979) and anchovies (Garcilaso 1609; Mason 1957; Donkin 1979). "Anchovies were important to agriculture as the ultimate source of fertilizer" (Lanning 1967:8). Prehistorically, fertilizers may have been used directly as they are today.

Fertilizing was also used in conjunction with fallowing. Llama dung fertilizer (Julian 1985) and fallowing of fields have an important connection, especially in highland agriculture, to offset the lack of natural soil nutrients. Quinoa (*Chenopodium quinoa*) and some other native grains need large amounts of nitrogen. In addition, potatoes (*Solanum tuberosus*), the most important highland staple, depletes nitrogen. Fortunately, nitrogen depletion is countered by llama (*Lama glama glama*) and alpaca (*Lama pacos*) dung which are both easily acquired because each herd has its own place where all members of the herd defecate (Orlove 1977:25-27).

Risk Management

A form of risk management is the utilization of different production zones in Peru although access to the products from these various zones may be limited to members of a certain *ayllu* or community. Agriculture is spread across hundreds of meters of elevation in these production zones. For example, maize can be raised up to an elevation of 3,500 m, while the indigenous tubers and cereal grains will still produce at elevations of 3,500-4,100 m (Brush and Guillet 1985)

Pasturage for camelids is located in the highlands (*altiplano*) above 4,700 m. The productive area for grazing plants and grasses

is increased by the use of *bofedales*--digging channels out from a spring source to increase the total area that it can water. The most important limiting factor of land use in all of Peru is the availability of water (Guillet 1992), and precipitation is both seasonal and sometimes unpredictable. Without such risk management systems, farming and, even survival itself would indeed be a risky endeavor.

Originally studied in the Alps, "Alpwirtschaft" is one of the more important risk management strategies that is utilized in other high altitude landscapes, such as the Himalayas and the Andes (Orlove and Guillet 1985). Known as "Verticality" in the Andes, it traditionally involved the exchange of commodities from several isolated production zones--"Islands"--with members of one's own *ayllu* (kin group) or the outright giving of commodities to one's members in times of need (Murra 1978). Such trade was still being practiced between the highlands and the coast during early Spanish Colonial times.

The Lupaqa had colonies in the Moquegua and Sama Valleys (Murra 1964), where the "caciques" {leaders} had small farms of Maize. The highland dwellers would trade potatoes and quinoa for corn and wheat which would not grow at extreme high elevations. Likewise the coastal natives traded corn for Llamas, wool, and *Charqui* (dehydrated llama meat) that they could not produce. Both the natives and the Spanish carried goods from the highlands to Ilo. One *fanega* (2.58 bushels) of potatoes would be exchanged for 10 *fanegas* of corn (San Miguel [1567] 1964:17-18).

The sharing of comestibles in dire periods of highland drought has allowed the residents of the altiplano to survive their harsh

surroundings for millennia. "Since droughts are regular occurrences, cultivators think in terms of long-term drought..." (Browman 1987:175). Juan de Santa Cruz [1620] tells of a great seven year famine (undoubtedly caused by severe drought) during the reign of Amaru Tupac Inca, son of the great Pachacuti. Conditions in Cuzco were such that grain had to be brought to Cuzco from distant farms (1872:97-98). Therefore, since drought is such a potentially devastating and regularly occurring highland phenomenon, all of the above mentioned traditional risk management techniques must be continually used.

The effects of a severe drought in 1982-83 is recorded in the Ucrupata Glacier. Investigations show that the snow and ice levels of the glacier were 3-5 m less than usual because of the lack of precipitation and warmer temperatures (Francou 1992:107). In this year, sixty percent of the potatoes and tubers and 70 percent of the grain production were lost to drought (Browman 1987:175). Unfortunately, statistics for the loss of human life associated with this great drought are lacking. Traditional water management systems had been replaced by "modern" technology, and no longer were the safeguards provided by the old system of sharing when need arose in the highlands. Thus, the drought of 1982-83 had a more severe impact on the southern Andes than droughts in the past.

With a surplus of food, storage became an important aspect of risk management against leaner times. Potatoes and also llama meat, were dehydrated using the naturally cold, dry night air. Concerning storage, Sancho [1550] writes, "All these large cities

have storehouses full of things which are in the land . . . " such as maize, vegetables, and tubers (1917:150). Pedro Pizarro [1571-based on his observations from 1532-1555] reports a similar sight- "The storehouses, which there were in this valley (Xaquixaguana, now called Sacsahuaman), and from here to Cuzco, {held examples of} all the things which were in the kingdom . . . "(1972:246-247).

Mainly the Inca, but also some of their forebears, had built a vast system of storehouses (*Collqas*) throughout the empire. These impressive towers of stone held not only comestibles, but clothing and other equipment which could be used by both the *Mit'a* laborers and the Incan Army. It is recorded that there was enough food and drink in storage to adequately feed 20,000-30,000 people (Zárate 1933:48). When food was taken from the storehouses, it was understood that it would be replaced with new food later on, so there would be a constant supply. These storage facilities served another purpose: Moving armies would use the stored goods and leave the food resources of the local inhabitants unmolested.

Evidence exists that, ever since prehistoric times, the Peruvian people were aware of their precarious existence. Food resources, such as fish, fishmeal, and vegetal products were accumulated and stored in mass quantities. Large, permanent storage facilities have been found at El Paraiso, the largest preceramic site with monumental architecture in the Western hemisphere (Moseley 1992:119). Also, the location of these units suggests that there was a high priority for defensibility (Jackson and Stocker 1982:23), perhaps from others not so well prepared for

dire times. Maybe the old notion of sharing with those in need had already begun to fade.

Contribution of Agriculture to the Prehistoric Diet

The indigenous population was decimated by smallpox, measles, and influenza after the arrival of the Conquistadors and even today it is still one-half of its Pre-Hispanic level (Guillet 1987). The population in the Central Andes alone declined by two-thirds from 1520 to 1570 and continued to decline until about the end of the 18th century. A case in point is Chincha, where in the 1530s there were 30,000 natives paying tribute, but by 1600 it was stated, "*ahora no hay 600*"--{Today there are not 600}--(Lizárrage 1968:44). Even today the native people, especially those in the highlands, need a sustainable agricultural system that will, at least, provide them with the minimum of calories needed for survival. In an effort to augment the unreliable food supply, some of the raised fields around Lake Titicaca have been reactivated (Kolata 1987).

Yet some scholars seem unsure and rather ambivalent on this point. Horkheimer (1990), for example, points out that the Peruvian people were better fed by the prehistoric food production system than they are now because much land today is devoted to the production of cash crops largely for export. However, elsewhere he asserts that the modern highland diet is superior to the prehistoric diet, based on his research conducted in 1968 (and funded by FAO). Lorandi (1987), too, seems somewhat equivocal when she agrees with Horkheimer and Murra (1980) that "there is no shortage of descriptions of famines in the work of 16th century

chroniclers." (:37), yet she goes on to list the various "ritual and state measures undertaken to fend off such critical conditions," as reported by these same early historians.

The diet of Tawantinsuyu was well-balanced and, in fact, superior to the nutritional requirements that are today theoretically set for humans (Mayolo 1981:30). Rostworowski (1988) agrees, maintaining that because diverse hydraulic systems along the coast permitted cultivation of the deltas and part of the adjacent desert, "the chroniclers did not find hungry people or malnourishment there" (1988:251). The excellent quality of the diet of Pre-Hispanic populations is further reinforced by one such chronicler, Guaman Poma de Ayala [1613], who informs us that "the natives had more than enough food" based on the numerous gifts of maize (*Zea mays*), potatoes, *oca* (*Oxalis tuberosa*), *ulluco* (*Ullucus tuberosus*), *quinoa* (*Chenopodium quinoa*), and *Llamas* given to the Spaniards (1980:55).

Religion and Agriculture

Background

Unlike Christianity, past Andean religious life had little to do with abstract expressions. Instead, worship often focused on *huacas* associated with particular kin groups or villages (Avila [1598] 1991:4). "*Huacas* are energized matter, acting within nature, not outside of it as Western supernaturals do . . . "(Avila, 1987:19). "Every summit, every gorge, every spring, in short, every site more or less prominent is thought to be inhabited by such a spirit" (Bandelier 1910:100).

Role of the Gods in Agriculture

Since most of the indigenous populations depended heavily on agriculture for their existence, all gods that controlled the various environmental elements that affected agriculture, both beneficially and adversely, were greatly venerated. Thus, in a hyperarid environment, the gods of lightening, rain, rivers, springs, and land would be the logical ones to become the most important (Rostworowski 1983). However, imbued with such an belief system, native Peruvians should have been psychologically vulnerable to any natural disaster which adversely affected their agriculture, and, in turn, a change in the agricultural base associated with a certain set of native deities could have produced a change in the native ideology.

Although the native pantheon included literally dozens of greater and lesser gods, *Pachamama*—mother earth—was the most fundamental of these deities. Since native agrarian cultures are so dependent upon the earth for many of their basic necessities, libations and offerings to *Pachacama* are a ubiquitous practice. Even today, whenever native Peruvians drink, many of them sprinkle a few drops of liquid on the ground to propiate mother earth. Further, potatoes or rocks are often wrapped in coca leaves and buried in the ground in the hope that *Pachacama* will provide them with an abundant crop. These practices demonstrate the dependence that the people felt toward *Pachacama*.

The complementarity of the male and female gods' relationships reflects a very worldly nature. The natives revered

Chaupi Ñamca, the supreme female deity and wife of Pachacamac, because she controlled the land. *Collquiri*, a highland god, controlled the wild, headland waters that flowed downhill to the lowland land. Once when *Collquiri* was lusting after the land *huaca's* daughter, his overflowing desire created a major flood. However, after a productive "marriage" between "water" and "land," irrigated agriculture came into being. Obviously, "the hydraulic embrace of moving water and enduring earth was imagined as sex" (Avila 1991:8).

One of the most frequently mentioned deities in the chronicles is, *Pariacaca*, renowned in the Central and Southern Andes as a powerful god who started torrential rainstorms, with red and yellow hail {perhaps, "ball" lightening}, in the mountains. According to native myths, *Pariacaca* is credited with washing away an entire *Yunga* {coastal dwellers'} village into the ocean (Could this be a reference to the village at Miraflores Quebrada? See Chapter 8). Some ingenious villages survived by channeling excess water onto the fields and into reservoirs. *Pariacaca*--five brothers residing in one entity--could also cause cold and hail by swinging their *bolas*. It is quite apparent that the durability of such myths reflects the highland peoples' tenacious attachment to the local resources on which they depend (Avila 1991:5).

Adoration of Huacas

Because of this obvious connection between early agricultural practices and the religious beliefs of the people, a more careful look

at some of the specifics of these beliefs is essential to a true understanding of their methods and practices.

Huaca is the native Quechua name given to myriad sacred objects, such as mountain passes, large stones, rivers, the sun, the moon, the earth, and forests, (Acosta [1604] Vol. II, 1970:301). The veneration of *huacas* was such a common custom in extreme northern Peru that each person had his own god according to his trade or office (Zárate [1555] 1933:11). According to Squier (1877), one of the most famous *kakas* (*huacas*) at Lake Titicaca was the "Holy rock of Manco Capac" (1877:335).

Possibly the most sacred of the *huacas* were the *Mallquis*, the mummified remains of ancestors (Avila 1991:16; Santillan 1950). "They had a care to keep the bodies of their kings and noblemen whole, from any ill scent or corruption above two hundred years" (Acosta Vol. II, 1970:312). Such great reverence was given to mummies that they were dressed in fine clothing and carried about on litters during special occasions. *Huacas* were carried into war and in processions when asking for rain or fair weather (Acosta Vol. II, 1970). They were even fed and given something to drink {probably *chicha*} (Guaman Poma [1615], 1980:251; Figure 3-3)

Mummies were extremely important to the natives because "many Andean groups traced their ancestry to sacred bodies, such as stones, statues, stelae and mummies" (Moseley 1990:29). As long as mummified bodies endured, both fertility and order would continue (Avila 1987:49). However, were an ethnic group to lose their *huaca* for some reason, the group believed that it lost all power associated with it. The capturing of an *ayllu's* mummy was

Figure 3-3: Mummy Being Carried on a Litter

known as "*Huaca* Hostage," and "holding it hostage would place veneratorsin bondage and promote subordinate behavior" (Moseley 1990:29). Gonzalo Pizarro used this tactic to gain more control over the natives at Sacsahuaman, where he not only captured the *huaca* of Inca Virachocha, but burned it" (Gamboa [1572] 1942:162).

Myths and rituals were attached to many local features, especially mountains, springs, lakes, and irrigation canals. Although there are several versions, the most popular origin myth for the Incas is one which claims that the original two Incas, brother and sister, were placed by Viracocha in Lake Titicaca (de la Vega [1609], 1966:40). Other myths concern themselves with powerful, ancient gods, such as *Tunupa*, who was very influential on the coast and southern sierra before the rise of the oracle of the cult of Viracocha. He was so omnipotent that he once destroyed a village, which rejected his preachings, by "throwing fire" and melted the neighboring mountain "like wax" (Rostworowski 1983:26). Of course, this sounds very much like what a large volcanic eruption could do to a small village.

These cultural traditions, associated with the veneration of hallowed places, were an integral part of native life during Spanish Colonial times, despite the proselytizing of Christianity (Avila [1598] 1991:5). Ritual was so ingrained in the native psyche that entire *chacras* {small farms} were devoted to growing corn for the manufacture of *chicha*--corn beer--consumed during the various rituals (Avila 1987:291). Some of these ritualistic traditions still survive today because the Aymara speakers continue to worship

Tunupa as the god of lightening and also to identify him with volcanoes (Rostworowski 1983:27).

"{The indigenes} had the idea that all gods had a duplicate at their disposal {on earth} in the same way each Inca possessed a *huaca* or brother" (Rostworowski 1983:21). A mirror image was expressed in body parts of the arms, legs, ears, eyes, breasts, and testicles. This image also had the oppositions of left and right, and upper (*boca*) and lower (*ano*). These oppositions are reflected in the divisions of *hanan* (upper) and *hurin* (lower) Cuzco and in the two halves of each *ayllu*, which can also be viewed as upper and lower and left and right (Rostworowski 1988). Perhaps, the upper and lower dichotomy applies equally to the highland and coastal religious centers, Titicaca and Pachacamac, respectively. The voice alone is dissimilar. Thus, these mirrored parts, along with the addition of one separate voice that functions for both halves, compose a "Triad," much like that expressed in Christianity (Rostworowski 1983:22).

Oracles and Religious Centers

Throughout much of their lengthy cultural history native Andeans have had a great proclivity for oracles and predictions of the future. No great act was ever undertaken without first consulting an oracle or soothsayer whose job it was to extract the palpitating heart of a camelid and predict the future (Zárate [1555] 1933:40). "Sorcerers" even made predictions by divining maize and *llama* dung (Molina [1584] 1873:14). Prognostications likewise were made according to the movement of astral bodies

(Rostworowski 1988:208; Santillan [1562] 1950; Anonymous [1615-21] 1950). The movement of the "Dark Constellations"--the black voids between the stars and constellations--were quite important, as well, for predictions and decision making (For a full discussion of this phenomenon, see Urton 1984:169-191).

The belief in the significance of these celestial movements and their consequences for native pastoralism and agriculture is made clear in the following account written by Avila in 1598. *Yacana*, the water bearer and the animator of llamas, was seen in one of these "dark spots." *Yacana* must drink water from the earth, lest there be a catastrophic flood. However, if he over-indulges, then there would be a severe drought. To appease *Yacana*, men lived by and tended the springs to ensure that water flowed for both the fields and the camelids (1991:132-134).

The faithful "traveled as far as 300 leagues" (about 1,200 km.) to make offerings of gold and silver or to make sacrifices to the idol at Pachacamac (Figure 3-4). When sacrifices were made, the idol would "speak" to the servants of the sanctuaries (Estete [1533], 1872:82). It is often stated that offerings and sacrifices made to all the powerful *huacas* consisted of many items including: men, women, and children; both coastal and highland crops, such as *coca, maize, oca, ulluco, llama, chicha*, flowers, and herbs (Cobo [1653] 1979; Guaman Poma de Ayala [1615] 1980; Gomara [1552] 1941; Pizarro [1533];1872; de la Vega [1609] 1989; Calancha [1639] 1972).

Before the start of the planting season in Cuzco, 100 *llamas* and 1,000 *cuys* {guinea pigs} were sacrificed to the local *huaca* in hopes that neither the sun nor water would damage crops (Guaman

Figure 3-4: Major Sacred Huacas (▲) of Peru

Poma de Ayala [1615] 1980:223). It was said that the practice of making offerings and sacrifices to the gods was so essential to the native population that "each month they sacrifice their own children, and with the blood they anoint the faces of the idols and the doors of the mosques (temples). The Spaniards found in many of those temples of the Sun, certain great earthen vessels, full of dried children, which had been sacrificed" (Zárate [1555] 1933:40).

Since the Spanish were so enamored of justifying their right to conquer, to rule, and to convert the "Naturales" to Catholicism, their accounts were sometimes gross exaggerations. At least one early chronicler relates an entirely different version concerning human sacrifices. Anonymous [1615-1621] states "pero el mayor borrón o falso testimonio que Polo {de Ondegardo 1560} dijo de los Peruanos, fué, que ellos usaron sacrificar hombres adultos y niños para diversas necesidades" {But the greatest blemish or false testimony that Polo said about the Peruvians was that they used to sacrifice adult males and children for diverse necessities} (1950:140). Such accounts by Polo were his own conjectures, according to this anonymous 16th century source, because "there was a very ancient law prohibiting sacrificing of humans or human blood because it was the cruelest thing and belonged to savages" (Anonymous 1950:141). Further, when the Incas conquered a cannibalistic tribe, they ordered the tribe to cease their practices, under threat of death--"Neither were they allowed to sacrifice adults nor children" (Anonymous 1950:141)

Offerings were made according to what pleased a particular god. *Huallallo*, the god of fire and *Pariacaca's* (see below) arch

rival, had a fondness for the spiny oyster shell (*Spondylus Princips*) (Avila 1991:66; Anonymous 1950). However, this mollusk is not native to the Central Coast of Peru, but it lives in the warmer waters off the coast of Ecuador. Therefore, Spondylus shells had to be imported from Ecuador by the Chincha "merchants" who were conveniently sponsored by the Pachacamac priesthood (Shimada 1991:xlvi).

There were *huacas* (houses of adoration) in every province of Peru (Acosta [1604] Vol. II, 1970:325), and Ondegardo [1560] states that there were more than 400 of them (1873:154). But, nevertheless, for centuries, there were only three major religious centers in the whole of Peru--the Temple of the Sun at Cuzco, the Temple of the Sun at Titicaca, and the sanctuary at Pachacamac (Figure 3-4). The latter shrine was considered "the Mecca of South America (Squier 1877:72). Pachacamac was the only coastal site where the wealth of the Inca Empire was collected (Hyslop 1986:263). Although there were other noted branch *huacas* at Quito, Chincha, and Huamachuco (Rostworowski 1988:208), which kept portions of the offerings (Burger 1988), the two most powerful *huacas* were Pachacamac on the coast and, Titicaca in the sierra (Rostworowski 1983). On the coast, the natives said that Pachacamac gave them life; while in the highlands, the Incas said that Titicaca gave them life (Avila 1991:329).

The importance of these consecrated places is emphasized by the fact that two of these sanctuaries experienced phases of substantial rebuilding. After the collapse of the Wari, ca. 700 A.D., there was a renaissance at Pachacamac and intensive construction

of pyramids with ramps (Shimada 1991:xxxiv), but it was Topa Inca who built the sumptuous temple at Pachacamac (Cabello Valboa 1955:338). The results must have been impressive because de la Vega [1609] notes "this temple of Pachacamac was very splendid, both as regards its buildings and their contents: It was unique in the whole of Peru . . . " (1989:380). Pachacuti Inca Yupanqui rebuilt the Cuzco shrine in a splendid manner (Cobo 1979:134) and renamed it *Coricancha*--the "Enclosure of Gold." This shrine became the exclusive cult of the Inca Empire and was transmitted to everyone, but it did not affect the veneration of local huacas throughout the Andes (Rostworowski 1988:76).

"The religious change in Cuzco did not affect the veneration given to the multiple *huacas* and existing idols within the boundary of the Andes" (Rostworowski 1988:76). In fact, nothing seemed to deter the indigenous population from worshipping their *huacas* because the custom was still very much in force more than 80 years after the Spanish Conquest and the proselytizing of Catholicism. Thus, in 1617 began the "Extirpation of Incan Idolatry." For four years, there was a true mobilization against the surviving idolatrous rites among the native Peruvians. The hiding places for the *huacas* were discovered, and the Spanish destroyed 1,769 principal idols, 7,288 lesser ones and burned 1,365 preserved, venerated bodies of the ancestral population (Vargas Ugarte Vol. II, 1954:153-158).

"It appears that Pachacamac was the most influential ceremonial center on the Central Coast and received labor services and tributes of a wide range of material goods from agricultural communities and polities on the Central Coast, adjacent highlands,

and beyond" (Shimada 1991:xlii). Pachacamac's status is attested to by the fact that there are an estimated 60,000-80,000 burials in the large necropolis partially excavated by Max Uhle in the early 20th century. The crowding of the cemeteries was attributed to the fact that so many ancient Peruvians wanted to be buried at Pachacamac. Highland foods, such as *Chuño*, *ulluco*, *quinoa*, and short-eared maize, found in the graves at the Sun Temple at Pachacamac, are possibly good indicators that the sierra people wished to be buried there (Uhle [1908] 1991:12, 18, 84). According to Zárate [1555], all principal people were carried to be buried in the province of Pachancama {Pachacamac} (1933:37).

Since earthquakes and tremors are a common occurrence along the entire length of the Peruvian littoral (Silgado 1978), the Pachacamac priests easily extracted considerable quantities of goods from the people using the threat of Pachacamac causing earthquakes (Shimada 1991). Offerings of *Chicha*, *Llamas*, and burned cloth were commonly used in an effort to placate the angry {seismically active} earth (Santillan [1562] 1950:58). Besides goods, the caretakers of the shrine began to appropriate surplus labor, which gave even more hegemony to this already powerful site (Patterson 1985). The natives believed that when Pachacamac was angry, the earth would shudder; if he were to turn his face to the side, the earth would quake. But worst of all, if Pachacamac should move his body, the world would come to an end ("si moviera todo su cuerpo, el mundo acabaria"; Avila 1991:335).

Unfortunately, such severe warnings did not intimate the Spanish, who had easy access to Pachacamac because it was an

important regional religious and political center on the Inca road system (Hyslop 1986:249). Because the desert and the broken topography restricted both communication and the trade of religious items, this road system was extremely important (Lanning 1967). After taking the gold and silver offerings from Pachacamac, Hernando Pizarro ordered the main vault pulled down (Estete [1533] 1872:83). "This captain {Hernando Pizarro} knocked down idols {and} broke the main idol to pieces; this was the one through which the devil {oracle} spoke" (Cobo 1990:89).

Environmental Stress

Constant Stress

People residing in the high elevations of the Andes are subjected to a number of constant stresses. With, perhaps, the exception of the Himalayan Mountains, no where else on earth must people continually adapt to the environmental stresses of a "not-over-salubrious climate" (Bandelier 1911:218) with elevated levels of solar radiation (Acosta Vol I, 1970; Moseley 1992), extreme cold (Bowman 1968; Murra 1978; "Cold so bitter as to wither the grass and benumb men and animals alike" Acosta Vol I, 1970:97), high winds (Acosta Vol I, 1970; Brush 1977), and hypoxia {lack of oxygen} (Acosta Vol I, 1970; Moseley 1992).

Other environmental factors, such as poor, thin soils (Murra 1978; Donkin 1979; Guillet 1987; Horkheimer 1990), erratic rainfall and drought (Santa Cruz 1620; Cabello 1981; Lorandi 1986; Browman 1987; Kolata 1987; Guillet 1987; Moseley 1992), hail (Acosta Vol I, 1970; Erickson 1987), frost (Bowman 1968; Smith

1968; Acosta Vol I, 1970; Murra 1978; Cabello 1981; Browman 1987; Erickson 1987; Kolata 1987) short growing seasons, crop failures (Guillet 1992:173--total crop loss every 3rd year), and limited farm land, all adversely affect agriculture, and, therefore, the less than average yields (Mason 1957; Browman 1987:175-substandard yields in two out of seven years), in turn, often result in a substandard diet for highland dwellers (Moseley 1992).

Tectonics

The impact of earthquakes, volcanic activity, and tectonic uplift on early agriculture in general, and on canal building and maintenance, in particular, is one of the most important aspects of this problem, especially those events that occur in combination with a severe El Niño. "Most of the world's tectonic activity--earthquakes, volcanoes, and mountain building--is concentrated along plate junctions. The west coast of South America is such a junction" (James 1993:61). Because Peru sits at the convergence of two massive plates in the earth's crust--the Nazca and the South American--"there is considerable seismic activity within the upper 50 km of the overriding South American plate" (Berazangi and Isacks 1976:686). "Subduction of the Nazca oceanic plate beneath the South American continental plate makes the western margin of South America one of the most tectonically active areas of the world" (Sandweiss 1986:17). There is a wide belt of seismicity that follows the Peru-Chile Arc for 7,000 km from Venezuela to southern Chile (Plafker et al. 1971:545).

The angle of subduction varies according to the latitude of the region of Peru or Chile. The nearly flat, subducted Nazca plate has significant implications regarding the tectonics of the broad Andean Cordillera since the South American plate slides relatively easily over the Nazca plate preventing the build-up of a mantle wedge, which is needed for volcanism. However, at the same time, it is this lack of the wedge effect and the close proximity of the Nazca plate to the continental plate that also causes the buckling and uplift of the Andean Cordillera (Berazangi and Isacks 1979:538, 547).

It is this same subduction and interaction of the two plates that is the origin of the Central Andes orogeny (mountain growth), which has continued essentially unchanged from the Mesozoic to present times (James 1971:3340). The 6 cm/yr. rate of underthrust of the Nazca plate (James 1993:6) causes a slight vertical displacement each year. This evidence supports the proposition of a dynamic Peruvian landscape, which is contrary to the position of some authors who consider the Peruvian countryside to be static (see Farrington 1983).

Earthquakes

Unlike Plate Tectonics that produce gradual, almost unperceptible changes in the Peruvian landscape, earthquakes, on the other hand, frequently cause spectacular and immediate alterations of the terrain. "The most molested lands, by earthquakes, in all of America, are the plains and coasts of this kingdom of Peru" (Cobo [1653], 1890:213). As two 17th century travelers remarked, " . . . indeed a most dreadful circumstance, is

that of earthquakes, to which this country is so subject, that the inhabitants are under continual apprehension of being buried in the ruins of their own houses" (Juan and Ulloa 1975:203). Polo (1904) estimated that there were more than 2,500 earthquakes in Peru from the time of the Conquest until the end of the 19th century, and, furthermore, he adds that there were not many tremors recorded from 1600-1700 A.D. (1904:323) Earthquakes in the last 400 years have killed at least 80,000 people in Peru and caused damages in the tens of billions of dollars (Silgado 1978:8; Figure 3-5).

A greater part of Lima, the "City of Kings," was razed by a major earthquake in 1586 A.D. (Cobo 1890; Silgado 1978; Rivera 1983). 1590 A.D. was a very bad year for earthquakes--in Lima and Callao, many houses and business were destroyed (Vargas Ugarte 1949); Cuzco suffered damages from strong tremors; a strong quake violently shook Torata and Canańá {villages near Moquegua, 60 km from Ilo} (Silgado 1978). In 1687, Lima was once again struck by a huge earthquake which razed most of the Peruvian coast (Vargas Ugarte 1945:92; Silgado 1978:7). In 1746, most of Lima was destroyed by an earthquake that lasted three minutes. As a result of this quake, a big Tsunami destroyed the port city of Callao that adjoins Lima (Juan and Ulloa 1975:206).

Arequipa has had almost as many severe earthquakes as Lima. Major quakes seriously damaged Arequipa in 1582 A.D., 1600 A.D. (including the damage from the eruption of Huayna Putina), 1604 A.D. (Rivera 1983), 1821 A.D., and 1868 A.D. (Squier 1877:224). The 1604 A.D. earthquake produced a Tsunami at Ilo, which traveled a kilometer up the Ilo Valley (Cobo 1890). The

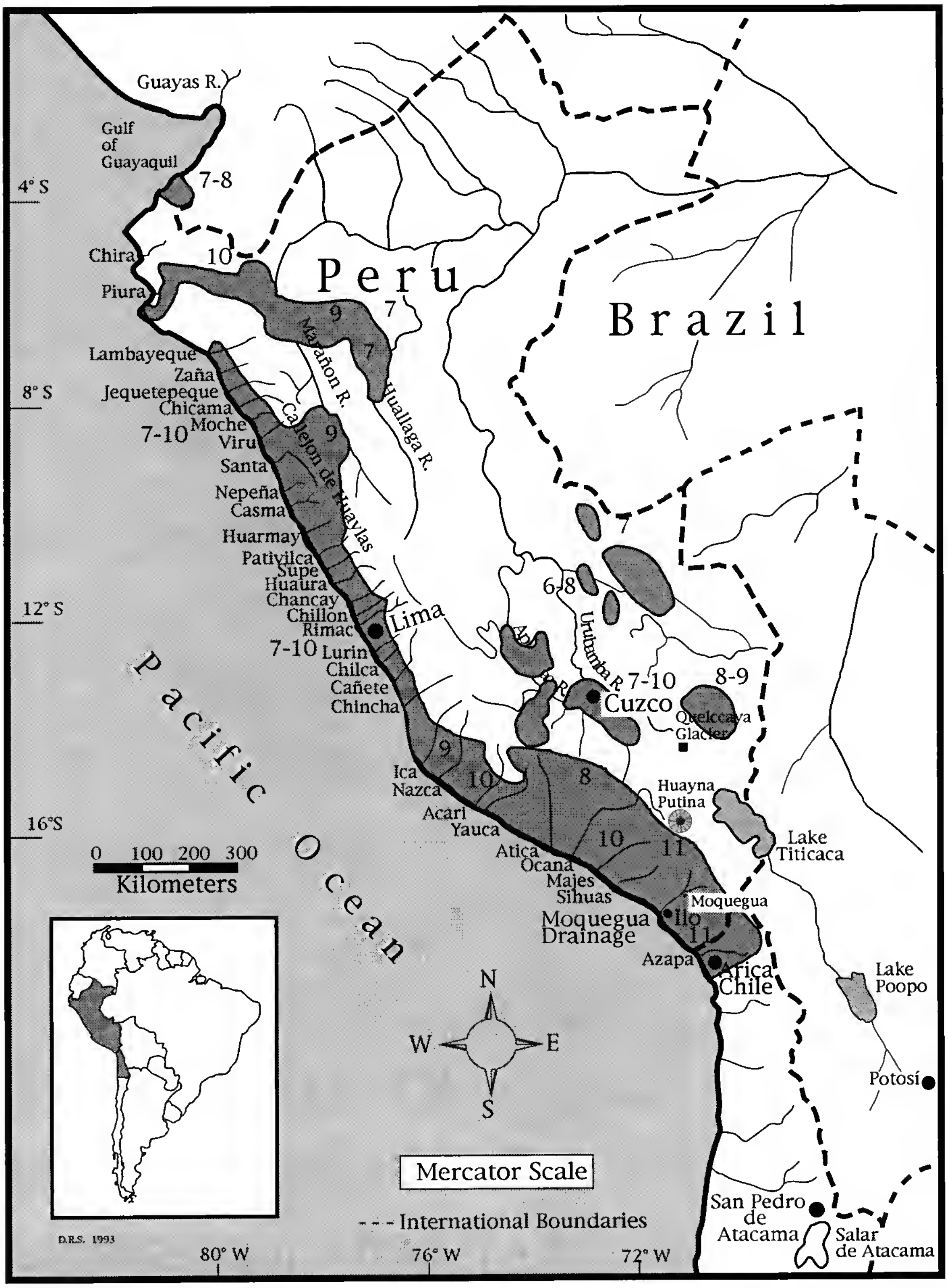


Figure 3-5: Distribution of Destructive Earthquakes: 1555-1974

1868 A.D. event caused a tremendous Tsunami with waves 16 m high at Arica, Chile (Rivera 1983) and destructive waves from this event even reached the coasts of Japan and Australia (Giesecke and Silgado 1981). According to Inca tradition, during the reign of Inca Tupac Yupanqui (1471-1493), a great quake destroyed the primitive settlement at Arequipa, including all the residents. To add to the destruction, at about this time, there was also an eruption of El Misti (Silgado 1978:16).

In Arequipa, 1582 A.D., an earthquake "overthrew the whole city." This same event caused some village streets to be flooded because it changed the position of the water table (Silgado 1978:17). The earthquake of 1586 A.D. caused a 27 m high Tsunami that ran inland for 8 kilometers (Acosta Vol I, 1970:179). This incident razed a great portion of Lima and caused damages as far South as Ica. At Callao, the sea level raised over a meter {*dos brazos*} (Silgado 1978:18).

The damage from the 1604 A.D. event, "*el espantoso terremoto*," was no less severe in Moquegua, 60 km upslope from Ilo, than it was in Arequipa. The earth opened up in many places, and there were rivers of foul-smelling, black water. The nearby settlements of Torata and Tumilaca were razed. Severely affecting the agriculture, the springs suddenly stopped flowing (Cobo 1890:220). Such tectonic activity probably affects spring sources which are nearer to the coast more than those farther inland because during the 17th century, there was an abundance of springs near Lima when the water table was only 4-5 feet below the surface (Juan and Ulloa 1975:219). Adding to this drop in the

phreatic level could be a drier climate which could also affect the drop in the water table at Lima, such as it has done in southern Peru (Clement and Moseley 1991). Possibly continual tectonic uplift has also affected the lowering of the water table (Moseley and Feldman 1984).

A great quake hit Trujillo in 1619 A.D. (Cobo 1890:226) and uplifted beachlines along the mouth of the Moche Valley (Nials et al. 1979). The damage was such that the inhabitants of the Santa Valley were forced to evacuate (Vargas Ugarte 1949:92). Cuzco was almost totally destroyed by the quake of 1650 A.D. (Cobo 1890:226; Torres Book IV, 1972:746).

Earthquakes are not exclusively a Peruvian phenomenon. As early as 1539 in Ecuador, a "marvelous, great earthquake occurred—the ground opened up in many places and swallowed up more than 500 houses." Accompanying this deplorable event was "rain with a tempest of lightening and thunder" (Zárate 1933:152).

In 1581, Chile suffered an earthquake so terrible that "it overturned mountains . . . blocking rivers and creating lakes . . . and beat down towns" (Acosta Vol. I, 1970:179). A dreadful earthquake in 1730 in Chile caused heavy damage as far South as Santiago. The city of Talcagua was totally inundated by a huge Tsunami as a result of the earthquake (Juan and Ulloa 1975:233).

Earthquakes not only destroy personal property, but they also can devastate irrigation canals, and can destroy the soil fertility. For example, the great quake of 1687 split the earth, releasing sulfurous clouds, whose precipitation altered the soil fertility so

much that sugar cane would no longer grow in the fields surrounding Lima (Juan and Ulloa 1975).

Tectonic Uplift

Prehistoric tectonics are also responsible for reshaping the Peruvian landscape by stranding beaches several kilometers from the ocean (Richardson 1983; Moseley et al. 1992). Total uplift since 500 B.C. is estimated at between 6-8 meters (Nials et al. 1979:8). Some authors do not totally agree with this statement. One study suggests that there is no evidence of Holocene tectonic uplift demonstrated in the Casma Valley (Wells 1988, 1990). Yet, Pozorski et al. (1983) state that the Casma Valley fossil bay, which sits 2-3 m above present sea level, could be the product of a change in sea level and/or tectonic activity (1983:408). Perhaps a change in sea level affected this fossil bay because Cardenas (1979) states there is evidence of a sea level drop, after sea stabilization, at the fossil bay of Salina de Chao where the sea receded almost 4 kilometers (1979:5). However, since the present sea level has remained basically unchanged since sea stabilization ca. 5000 B.P. (Rollins et al. 1986), tectonic activity seems the more likely catalyst for the uplift of this particular fossil bay.

Uplifted prehistoric marine terraces are evident in many regions of along the Peruvian coast. One marine terrace at Wawakiki, about 5 km from Pocoma, is over 100 meters above current sea level. The marine terraces at the Majes Valley, North of the Ilo Valley, have been uplifted 500 m since the Pliocene. The uplift was not uniform since there are three "notches" or steps

visible. The effect of the uplift is that the Majes River has downcut through these Pliocene deposits and formed an extensive delta from them (Bowman 1968:227).

Although this same non-uniform uplift is visible in the positions of the three large marine terraces along the coast at Ilo, recent studies at the Ring Site near Ilo establish that the rate of tectonic uplift is gradual being only 0.1 m per 1,000 years (Sandweiss et al. 1989). Thus, the Ilo coastline has risen only 1 meter in the last 10,000 years since the Ring Site was first occupied. This uplift rate is smaller compared to the Quaternary uplift along the rest of the coast of southern Peru and Chile, which has been calculated at 0.1 m to 0.5 m per millennia (Richardson et al. 1990). Although the sea-level has risen 35-40 m in the last 10,000 years (Dillon and Oldale 1978), this rise in elevation does not affect the interpretation of the relationship between the Ring Site and its immediate environment (Richardson et al. 1990).

Volcanic Eruptions

Since Peru sits on a convergence zone where the Nazca Plate collides with the South American Plate, Peru is not only one of the most seismically active areas in the world, but it also has a number of active volcanoes, which sit opposite the regions of steep (30°) subduction (Pitcher et al. 1985:12). Cobo exclaims "Volcanoes are a plague and a calamity for the coastal plains and the sierra" (Mateos Book II, 1956:95). Even neighboring Ecuador has had its share of volcanic eruptions. Quito was devastated by a violent volcanic

eruption in 1576, and people had to stay indoors because of the heavy ash (Acosta Vol. I, 1970:175).

Perhaps, one of most destructive eruptions of all times occurred in February 14, 1600 A.D. when Huayna Putina violently exploded (Mateos Book II, 1956:96). Huayna Putina was the most violent volcanic eruption in the Central Andes during historical times, that ejected 1 km^3 of material into the atmosphere (Bouysse-Cassagne and Bouysse 1984:47). The volcano erupted and covered the city {Arequipa} with ash and sand "que a medio dia pareció noche oscura" {so that at midday, it seemed like the dark night} (Calancha [1639] 1972:415). "For 30 days, people were unable to see the sun, the moon, or the stars" (Guaman Poma de Ayala [1615] 1980:973; Figure 3-6). For hours the "dry rain" fell and "darkened the air so that night and day were the same for little less than a month" (Torres [1600] Book II, 1972:79). For four days, the Arequepeñas also experienced violent earthquakes and more than 200 tremors. Rivers were clogged with rocks and the volcanic ash was level with the fields. Lakes as large as 6 leagues (15 miles) were formed, and when the rock and earthen dam breached, all the trees, vineyards, olive groves, and other agricultural products were totally washed away. Springs and smaller rivers became dry. The city was filled with many people who either died or were severely debilitated by hunger and thirst (Torres [1600] Book I,1972:79-80; Vargas Ugarte 1949:449).

Volcanic ash was carried as far as 300 leagues (750 miles) (Torres [1600] Book I, 1972:80). Arica, Chile, about 500 km Southeast of Arequipa, was also covered by the Huayna Putina ash

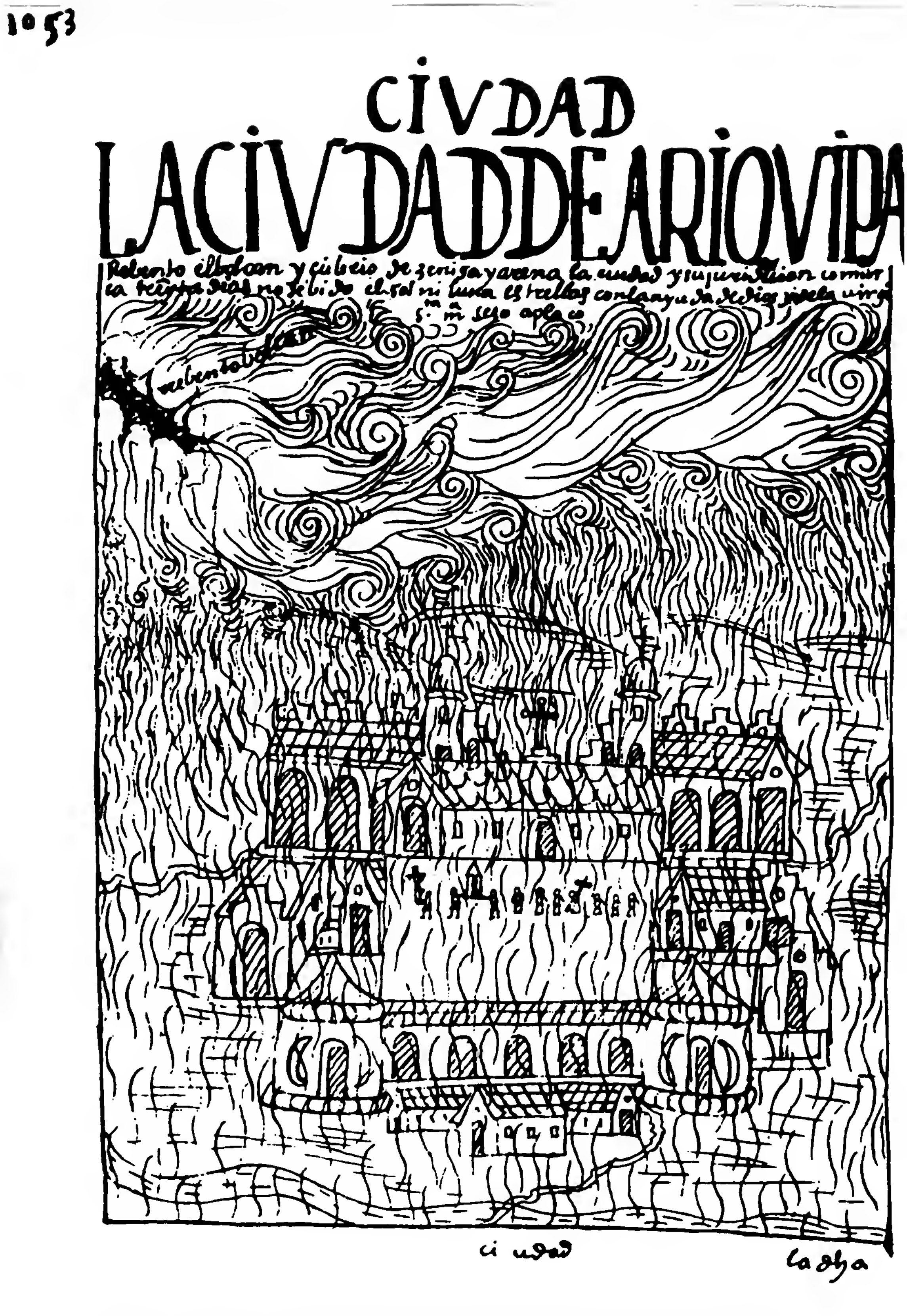


Figure 3-6: Arequipa During Huayna Putina Eruption

(Figure 3-7). In Moquegua and Torata, about 150 km from Huayna Putina, ash caused the loss of much property and the sterilization of farmland (Kuon Cabello 1985:35, 136). Volcanic ash covered "everything from the cordillera to the coast" (Vargas Ugarte 1949:575). Instead of rain, "*polvo triste*" {sad dust} fell from the sky on Lima (Torres [1600] Book II, 1972:690).

El Niño Rains and Floods

> In any given year, the rainfall and temperatures of a specific area are governed by a worldwide system of atmospheric circulation whose patterns are determined by the world budget of energy. Hence every local episode of climatic change great enough to leave archaeological evidence of its economic effect in the form of alteration of ground water conditions, of vegetation, and, ultimately, of fauna, indicates some modulation in the total world climatic system (Paulsen 1977:121).

What better event to cause such an alteration and leave irrefutable evidence of its occurrence in the archaeological record than a strong El Niño perturbation? Since climate is mostly independent of human existence, any major shift in climate should affect a cultural system in ways that are readily recognizable to archaeologists as changes of subsistence, population size and density, settlement location, trade and artifact assemblage (Paulsen 1977).

Since sea stabilization about 5000 B.P. (Richardson 1983), the modern climatic regime has been in place, and it is believed, based on the incursion of warm water mollusks, that the El Niño phenomenon has been occurring since about this time (Rollins et al.

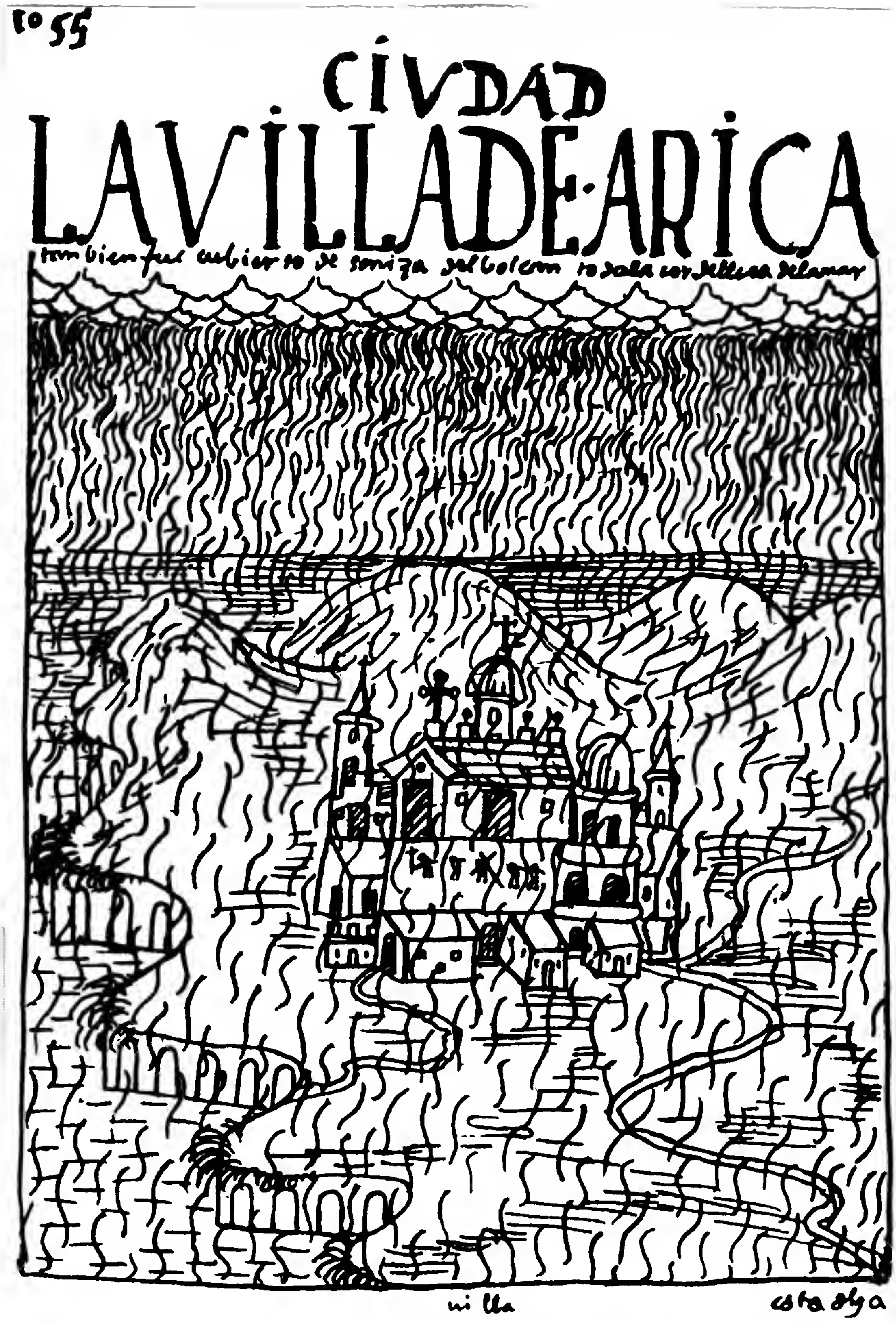


Figure 3-7: Arica During Huayna Putina Eruption

1986). However, evidence from the Quebrada Las Conchas in Chile suggests that El Niños may have occurred as early as 9000 B.P. (Elera et al. 1992). Wells (1987) would probably agree with this early date because she states that the flood plain stratigraphy of the Rio Casma suggests that the El Niño phenomenon has occurred throughout the last ten thousand years (1987:1134), because the distribution of warm water mollusks indicates that warm water incursions have happened during the entire Holocene (1987:1135). Further, she states that the warm water mollusks are "common to quiet restricted marine environments (lagoons and estuaries), and that they occur in association with cold-water open-marine fauna in early lithic archaeological sites near Casma . . . " (Wells 1987:14,463). Wells even has potential evidence from Rio Seco that might suggest that El Niños have occurred since 40,000 B.P. (1987:14,467).

To date, the most reliable means for recording paleoclimate change seems to come from the deep ice cores from the Quelccaya Glacier in southern Peru (Thompson et al. 1984, 1985, 1986, 1988), one of only two ice caps existing in the Tropics (Mercer and Palacios 1977). This is vital work because "archaeological evidence, when compared to ice cores, suggests that periods of flourishing highland cultures appear during periods when mountains are wetter than average, and coastal cultures flourish when mountains are drier than usual" (Thompson 1992:311).

In addition, some work is now being done with the weather changes recorded in tropical coral formations, which contain a thousand year record of the changes in growth, and cadmium and

calcium content which are affected by the El Niño anomalies. The cadmium/calcium ratios in corals from the Galapagos Islands, for example, correlate well with the 1965-1979 weather anomalies. However, for some reason corals were unaffected by nutrient limitations during the Little Ice Age (150-450 B.P.), which has led some to question whether El Niño is a persistent feature influencing the eastern tropical Pacific during the past few millennia (Enfield 1989:180-181).

Cobo [1639] speaks of a huge inundation which destroys all the houses in one quarter of Lima in 1578 (Mateos 1956:311). Normally it is very dry, "but, in years when northern and easterly winds blow, then it rains." In 1578, in Trujillo, "it rained abundantly; the which they had not seen in many ages before" (Acosta [1604] Vol. I, 1970:167). Testimonies from the 16th century Caciques {local native rulers} concerning this flood yield enough information to conclude that this "*diluvio*" was easily the most catastrophic event of the 16th century. Floods inundated and razed the entire region of northern Peru and produced a severe, widespread famine (Alcocer 1987).

Surely these accounts do not exaggerate the devastation, since a modern evaluation of this particular event rates it as "very strong," the highest category of heavy rains and devastation (Quinn et al. 1986:18). Cabello Valboa [1586] writes about the great inundation of 1576 (he most likely means 1578) that totally ruined Trujillo. "It was no less than any other flood that has occurred in the world. Ten years after the inundation, people still had not fully recovered from the damages" (1955:223-224).

Acosta (Vol. I, 1970) states that some observe that quakes usually happened when a rainy year occurs after several dry years. With reference to the 1581 earthquake, he states that a village near La Paz, Bolivia, was suddenly raised up and carried away, with many natives being smothered. Land slid, "like water or molten wax," for 7 km (1970:181).

Sometimes highland floods are caused by an inordinate snow melt during the Spring thaw. Zárate (1933) mentions such a flood that totally drowned one town because the force was so great that "it carried stones bigger than any millstone down the streams like a cork" (1933:97). One of the greatest natural disasters ever recorded in Peru was the result, not of an El Niño, but of the 1970 (7.7 Richter) earthquake that dislodged part of a glacier from the slope of Huascarán. The resultant rock, debris, and ice flood drowned and entombed at least 17,000 inhabitants of the town of Yungay (Oliver-Smith 1986) and was probably the most destructive landslide of this century (Keefer 1984). The avalanche involved 50-100 million cubic meters of debris that traveled 14 km to Yungay at an average velocity of between 280-335 km per hour. The quake affected 83,000 km^2 (ONI 1971:15) and 80% of all structures, within the afflicted areas, were rendered uninhabitable (Plafker et al. 1971:543). Additionally, in Huaraz, nearly 20,000 more people died as the result of this same earthquake (Dudadik 1978).

Concerning the coast, "the only mechanism of massive erosion in this desert region are the El Niños . . . " (Richardson 1983:275). Because of the massive amounts of materials moved from the land

into the ocean, El Niños have been identified as one of the sources contributing to the buildup of massive sand dune ridges in the Santa Valley (Richardson 1983; Rollins et al. 1986; Sandweiss 1986; Moseley et al. 1992). Only the Santa, Chira, and Piura Rivers carry enough sediments to sustain beach ridge development (Ortlieb et al. 1992:217) However, some believe that it is high waves from southeastern Pacific storms that build the beach ridges (Craig 1992:55).

Flood Studies Conducted in Peru

Introduction

Spanish Colonial records help to augment the archaeological record of Peru, especially where it concerns the Inca and their far-reaching empire of Tahuantinsuyu. Unfortunately, since the Spanish did not recognize Pre-Inca conditions with regards to any legal claims by the native population, these records are of limited use when investigating earlier times (Moseley 1992). The same can be said for early chroniclers and clerics who made some mention of large inundations in Peru which occurred during the 16^{th} and 17^{th} centuries. However, when the events under study are prehistoric, the archaeologist must rely heavily on the flood deposits and profiles left by these early inundations.

Previous Flood Studies

Until now there have been only a few previous studies of prehistoric floods in Peru, and these have focused mainly on the north coast. The far-South of Peru has been almost totally ignored

archaeologically except for some work done in the 1950s by Ghersi (1958). However, with the creation of the Programa Contisuyu in 1982, the area around Ilo has come under intense archaeological investigation. As a part of this new area of scholarship, this current study is the first to concentrate on the impact of a prehistoric flood event, of inordinate proportions, on a local ancient population living on the far-southern coast of Peru.

Moore (1988, 1991) analyzed the flood record left in the prehistoric ridged fields of the Casma River Valley. Although it has been proposed that these specialized agricultural surfaces were built to augment total agrarian output from irrigation systems (Pozorski et al. 1983), there is little evidence to support the idea since there are scant storage facilities in the Casma Valley. Moore (1988) believes that the agricultural structures "reflect a period of markedly high precipitation and runoff from a 14th century El Niño" (1988:273). This is most likely the same flood event that was recorded and studied in the Ilo area by this author. The Casma Valley ridged field system may be a part of the Chimu's post-flood agricultural strategy to drain the water-logged lands, which were presumably more productive than marginal lands (1988:274).

The effects of this 14th century event greatly disrupted the total Chimu agricultural system. "The crippling of the canal system by flooding apparently acted as a catalyst for a change in Chimu {agricultural} strategy" (Pozorski 1987:118). Because of the vast labor force available to the Chimu empire, some of the canal system could have been rebuilt and used after the flood. Since there was a loss of the marginal lands, most likely because from direct flood

damage, the Chimu formed additional military units and conquered the coastal land to the North and to the South from which tribute could be extracted to offset the lost agricultural production (Pozorski 1987). This is in stark contrast to the small Chiribaya polity which, after the 14th century flood, presumably did not have enough people either to rebuild their canal system or to invade another polity.

The Prehistoric Flood Record in Northern Peru

One of the earliest well-documented floods in Peru occurred in the first millennia A.D., causing the abandonment of the Moche V ceremonial city of Pampa Grande around 700 A.D. (Craig and Shimada 1986; Shimada 1990). This date might be a little late according to evidence from the ice cores of Quelccaya Glacier. Dust particles captured within the glacial ice indicate a prolonged 32-years-drought from 562-594 A.D. (Thompson et al. 1985; Shimada et al. 1991; see Martin et al. 1992 concerning a severe drought ca. 600 A.D.). On the south coast of Peru, mudflows cover all the Paracas-Nazca cultural materials (Gradzicki 1992:119), and, thus, these deposits could have been from the same flood and deposited sometime between 500-600 A.D.

Batan Grande, in the La Leche Valley, was abandoned ca. 1100 A.D. because of one of the largest and most devastating floods in Peruvian prehistory. While the coast was being inundated, the highlands were enduring an extended drought of 30 years duration around 1020-1050 A.D. (Thompson et al. 1984, 1985, 1986). There is also evidence at Pacatnamú that a major El Niño inundation

occurred at this time. The site was abandoned following the flood and later reoccupied, as can be seen by the entirely new brick type used in construction and the different ceramic assemblage (Donnan 1987, 1990).

The legend of Fempellac's (or Chimu) flood (see Chapter 2) was undoubtedly based on this appalling event. Fempellac, a 12^{th} generation ruler succeeding the founder, Nyamlap, (Cabello Vargas 1951:38), lived around 1100 A.D. (Donnan 1990:270). This same flood is recorded at Sican in the Lambeyeque Valley and is dated, according to intrusive Middle Sican burials, to around 1000 A.D. By 1100 A.D., much of the complex was abandoned (Craig and Shimada 1986:30, 36). Nials et al. (1979) date this event to "within a century of 1100 A.D." (Part II:9). The new Moche V site of Galindo was founded partially because of the flood after Moche IV and before the introduction of red, white, and black Chimu ceramics in the Early Chimu Period (Donnan and Mackey 1978), thus, placing the date for the flood at about 1100 A.D. (Moseley and Deeds 1982:39).

There is some confusion among scholars as to when Fempellac's Flood occurred. Pozorski (1987) believes that the flood happened around 1300 A.D. based on the ^{14}C data from the Casma Valley, and the fact that Cabello Valboa (1955) mentions a powerful "Chimo Capac" {Chimu leader} taking post-flood control of the Lambeyeque Valley after the flood. This date of 1300 A.D. is a vague possibility since it is around this time that the monstrous Miraflores Event, near Ilo in far-southern Peru, is dated (1350 A.D. +/- 45 PITT 0948; Satterlee 1991).

Although the Basal Sequence contains thicker deposits, the Miraflores Flood left some of the deeper flood deposits, for a single event, found in Southern Peru, and, further, this flood covered quite an extensive region. Therefore, its flood surge on the north coast could have been truly astounding. Therefore, it should have obliterated any smaller, earlier flood signatures in the Casma Valley, including those from an 1100 A.D. event, since the Casma is a much smaller drainage than is the Lambeyeque.

Wells (1988) interprets the ^{14}C dates of 1325 A.D. +/- 45 (SMU-1940), and 1380 A.D. +/- 140 (SMU-1669) as representing an approximate date of 1330 A.D. +/- 35 for the occurrence of a major El Niño. Wells (1990) offers additional possible ^{14}C dates of 1330 A.D. +/- 60 (ETH-3916) and 1376 A.D. +/- 135 (SMU 1669) that may correspond to this same flood event. "This 1330 A.D. date correlates with the radiocarbon dates for the flood event which destroyed the Chimu canal system North of Chan Chan" (Moore 1991:38; see also Pozorski 1987).

Since similar flood deposits were identified in front of the Huaca de la Luna, overlying Moche phase archaeological deposits (Nials et al. 1979:7), the 1100 A.D. date for Fempellac's Flood seems more realistic. According to a recent article by Ortloff and Kolata (1992) there should have been two major El Niño perturbations that transpired in 1100 A.D. and 1300 A.D., respectively. Mörner (1992) claims that Peruvian beach ridges, elevated levels of atmospheric Co_2, and some glacial advances all point to a Super-ENSO around 1100-1200 A.D. (1992:204). Evidence from Pachacamac on the Central Coast also indicates a major event ca. 1100 A.D. (Paredes

and Ramos 1992:225). Had Fempellac's Flood occurred in the late 14th century, there probably should be Chimu cultural materials underlying and/or mixed with the flood deposits since the Chimu Culture had already been in existence for 300 years.

Part of the confusion may result in the misinterpretation of Holocene flood deposits. "Episodes of destabilization and restabilization of vast quantities of arid land mass in motion during the last 5,000 years are of 'Pleistocene' magnitude but are mistaken for geological products of glacial episodes" (Moseley et al. 1981:239). It is true that some Pleistocene flood surges reached leviathan proportions (greater than 18 million cubic meters per second), but they usually left easily identifiable features such as flood-scoured channels, giant sand bars, or huge gravel wave trains (Baker et al. 1993:348). Since the northern Peruvian river valleys lack such features, the deposits in question are probably the result of massive El Niño flooding.

The Prehistoric Flood Record in the Ilo Valley and in the Coastal Quebradas Near Ilo, Far-Southern Peru

The Ilo Valley flood record can be divided into discrete flood sequences (Figure 3-8). The 1992 El Niño is the smallest and most recent of these events, which left small mudflows in the bottom of some rills and larger quebradas. Traces of adobe-like debris from the 1982-83 event can be seen plastered against the lower walls of the normally dry coastal quebradas. Further evidence of its occurrence is also visible on the dry floodplain of the Ilo Valley. The next noticeable flood is the very large post-1600 A.D. Chuza

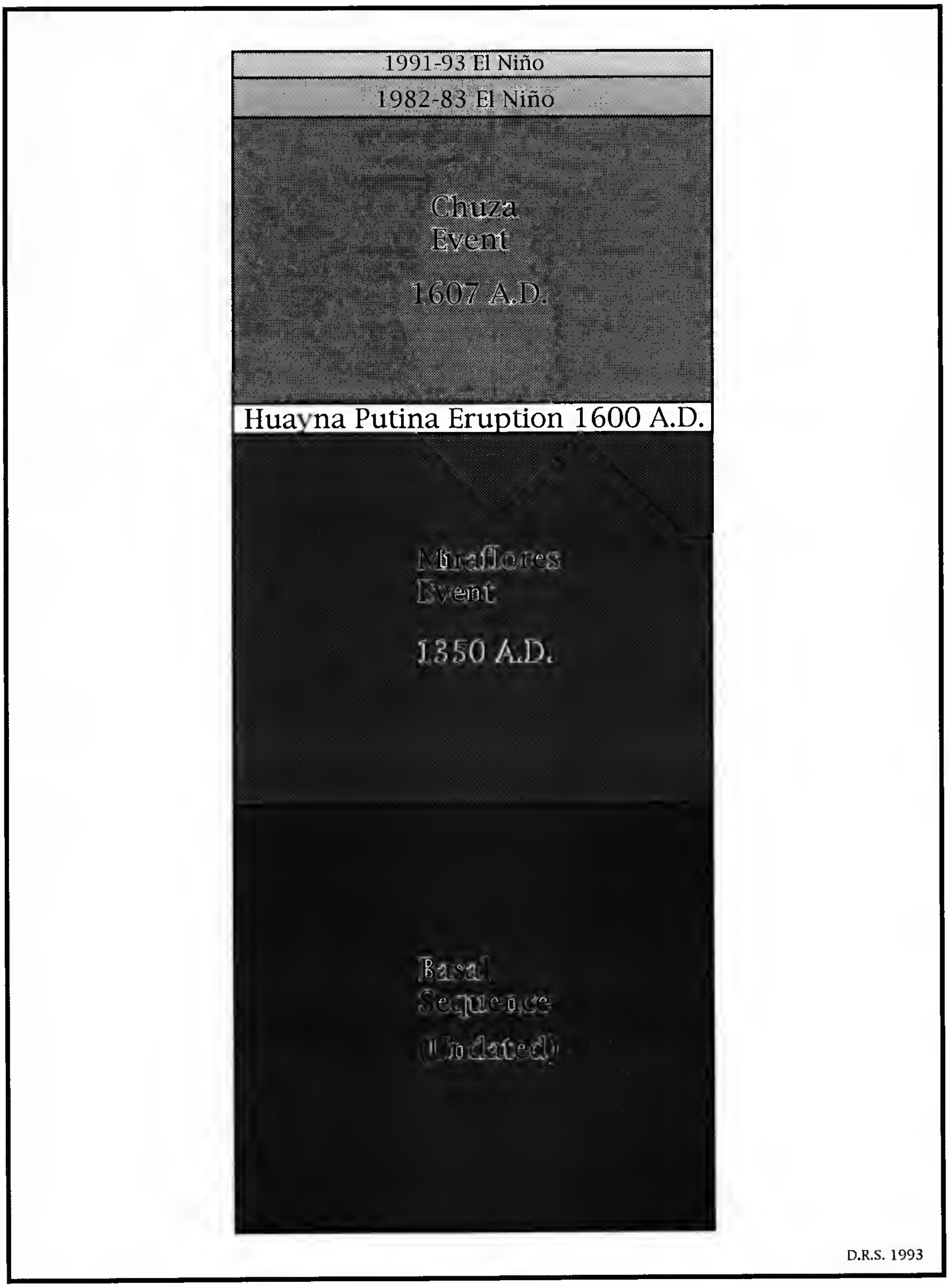


Figure 3-8: Sequence of Flood Events in the Ilo Valley (Not to Scale)

Event, which was first identified in 1989 at the Chuza Quebrada located on the coast about 12 km North of Ilo (Figure 3-9). The Chuza flood signature is composed of silt, sand, thousands of 1-5 cm angular rock fragments, and a few large rocks up to 60 cm in size. These materials are found in a stratum varying from 1-2 meters in depth. The Chuza deposits are characteristically brown in color, which is derived from the materials of the Volcanic Chocolate Formation that is prevalent throughout the Moquequa Drainage (Bollido and Guevara 1963).

Although the Chuza Flood has, until now, not been dated using ^{14}C, it probably occurred in 1607 A.D. during a significant El Niño Event (Quinn et al. 1986). The reason that this event left such deep deposits was the fact that it was preceded by major tectonic activity associated with the eruption of Huayna Putina, in 1600 A.D. (Vargas Ugarte 1949; Mateos [1639] Book II, 1956; Torres [1600] Book I, 1979; Guaman Poma de Ayala [1615] 1980) and again in 1604 A.D. (Cobo [1653] 1890; Squier 1877; Silgado 1978). Some authors disagree that 1607 A.D. is a probable date for this large El Niño, and they claim that 1624 A.D. would be a more accurate date (Hocquenghem and Ortlief 1992:147).

However, the 1624 A.D. date for the El Niño that produced the Chuza Flood does not seem correct for the following reasons. The 1604 A.D. *terremoto* was an event of phenomenal proportions. The effects of this cataclysm were felt for 1650 km North to South, and structures of all types were destroyed in the Peruvian cities of Arequipa, Moquegua, Tacna and in Arica, Chile (Silgado 1978; Kuon Cabello 1985). Its magnitude was estimated at an astounding 8.4

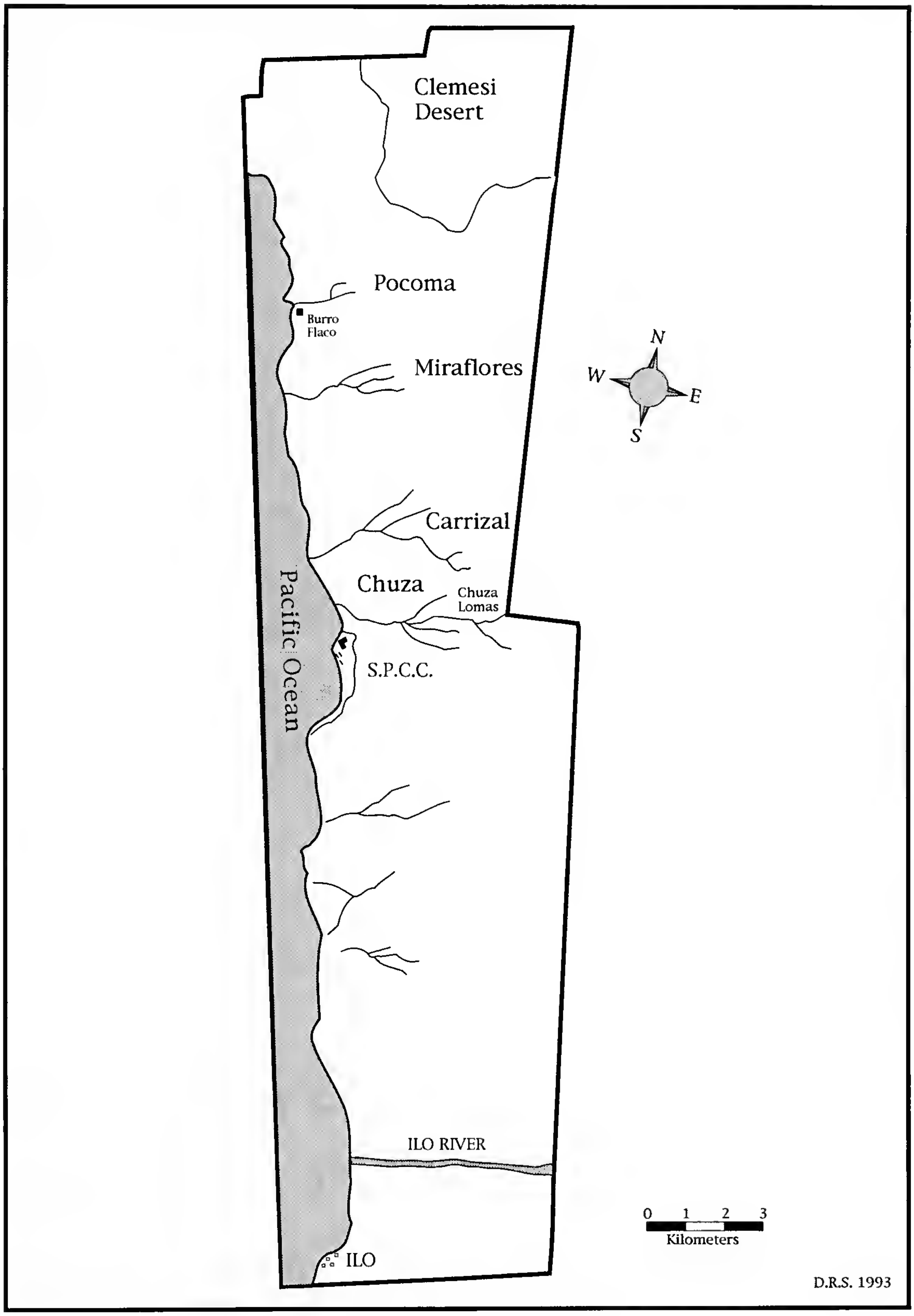


Figure 3-9: Ilo Coastline

on the Richter Scale (Silgado 1978:127). An event of this scope would have caused mass wasting and shaken and dislodged more than ample materials for water transport by El Niño rains. There was a 1615 A.D. tremor, which caused damages in both Tacna, Peru, and in Arica, Chile, but there were no damages recorded for this event in either Ilo or Moquegua (Kuon Cabello 1985). Furthermore, it was not a major event like the 1604 A.D. earthquake Therefore, Hocquenghem and Ortlief's (1992) claim for a date of 1624 A.D. for the El Niño which produced the Chuza Flood, does not appear to be accurate. Further, there was a strong El Niño event in 1618-19 A.D. which should have washed away any loosened materials from the 1615 A.D. quake. Therefore, unless the 1624 A.D. event were a rare Mega-Niño, which might occur every 500 or so years (Sandweiss 1986; Ortlieb et al. 1992), there should not have been enough loose materials to provide a massive flood signature.

At least one author (Mörner 1992) claims that there have been even rarer super-ENSO events, lasting 100-150 years, which have transpired about 16 times since the Holocene Period. However, there may not be records of such events in Peru since "major climatic changes and shifts, on the order of decades and centuries are found to be regionally induced, not globally induced (Mörner 1992:202, 203).

Beneath the Chuza Event deposits is a 1-3 cm layer of volcanic tephra deposited by the eruption of Huayna Putina from February 19 to March 6, 1600 A.D. (Thompson et al. 1986). This ash layer serves as a chronological marker separating the detritus of the two

largest late Holocene flood events--Chuza and Miraflores--found in the lower Osmore and upper Moquegua Drainages.

Below the volcanic ash are the deposits from the Miraflores Event, an episode named after a coastal quebrada about 6 km North of the Chuza Quebrada (Figure 3-9). This gargantuan event deposited 2-6 meters of silt, sand, riverine gravel, and small cobbles throughout the Osmore drainage. When the 1982-83 debris is compared to that of the Miraflores Event, the recent flood looks like a mere trickle. Comparing the depths of the deposits from these two events, the Miraflores Event could have been 10-20 times stronger than the 1982-83 event, which was the strongest event of the 20th century (Figure 3-10).

The characteristic pinkish color of the Miraflores Flood is probably derived from the Inferior Moquegua Formation, near the town of Moquegua, which is composed of sands and clays, shading from grey to pink, and pinkish feldspars and quartzes. Another source of this same colored material could also be the very large Quebrada Seca de Guaneros, which is composed primarily of pink sands and clays, that intersects with the Rio Osmore (Bollido 1979:36-37).

The earliest deposits visible in the flood record are those of the Basal Sequence (BS), which actually represents generations of prehistoric floods, some of which may have been as large or even larger than the Miraflores Flood. The BS deposits include large boulders, 20-50 cm in length, suspended in a matrix of well-consolidated slightly pinkish silt and sand, which occurs in depths varying from two to eight and a half meters. Unfortunately, at this

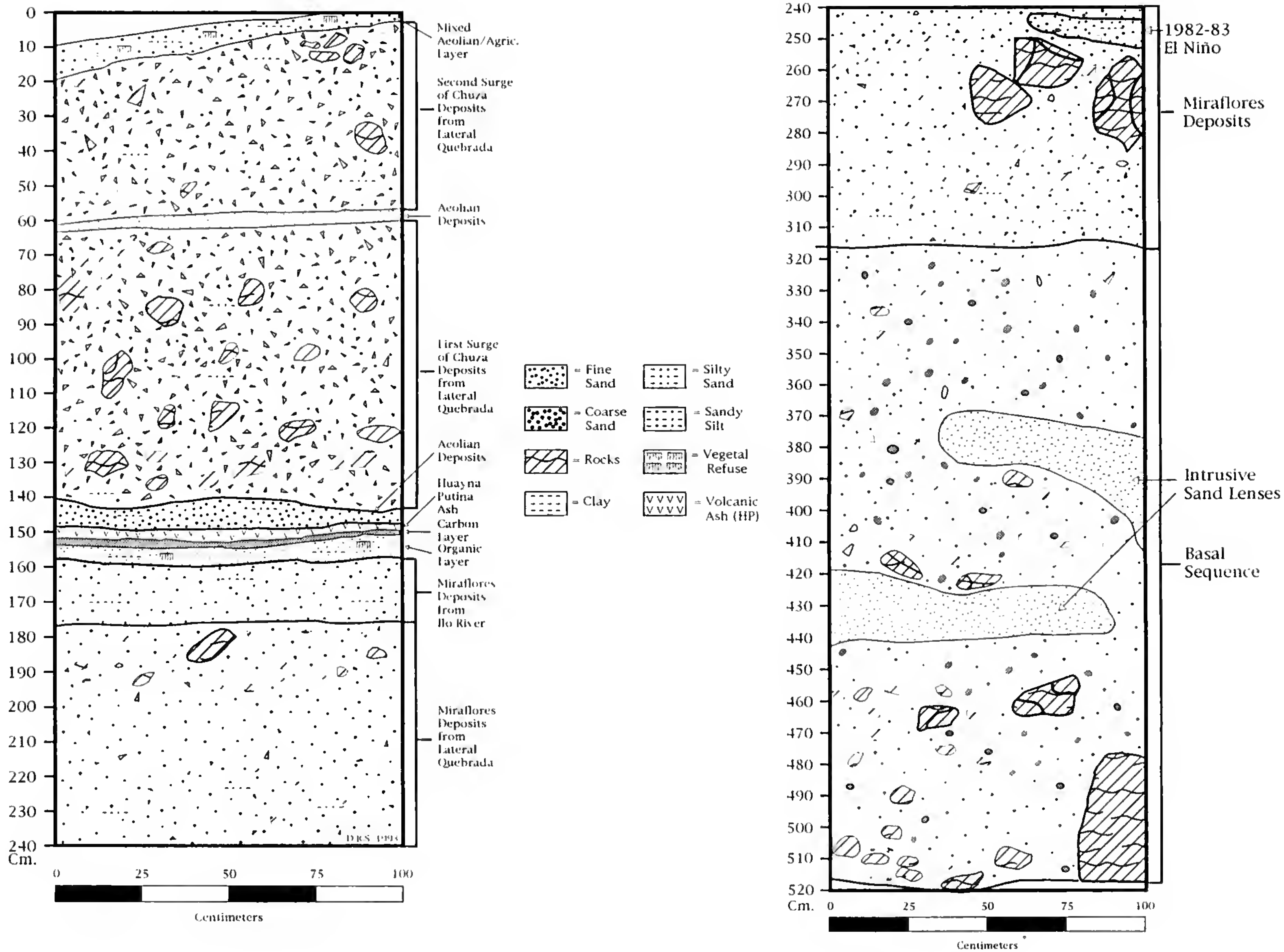


Figure 3-10: Geologic Column #1 at Planting Surface #1

time, it is impossible to effectively separate and to date each event within the Basal Sequence.

Analogous to the Nials et al. (1979) interpretation of flood deposits in the Moche Valley, if subsequent downcutting of the quebrada channel has occurred since the Miraflores Flood, then this result would make other later floods, such as the Chuza Event, appear to be smaller in volume because the channel would be deeper and, thus, hold more flood materials. Further, as has been suggested concerning large flood events elsewhere in Peru (Nials et al. 1979; Wells 1987), the inordinate size of the Chuza Event obliterated all the evidence of any earlier, smaller El Niño floods that may have reached far-southern Peru during the late 14th century until the early 17th century. For example, to date, there have been no indications found in the geoarchaeological record of the strong El Niños of 1541, 1552, 1567-68, or 1578 A.D. (Quinn et al. 1986). These same particulars hold true likewise for the 1982-83 El Niño deposits which expunged the deposits from both the 1891 and 1925-26 event, which were sizable perturbations.

Conclusion

Without written records to assist us, we must fully comprehend the complex cultural development of Peru in order to accurately interpret the archaeological record of the geographical region. Drawing upon the knowledge derived from the previous archaeological studies, we can only then slowly piece together the puzzle of Peruvian Prehistory.

Humans in diverse geographical localities have relied heavily on agriculture for millennia, with relative success for the most part, but it is in the hyperarid regions of the globe, such as Peru, that the technology of irrigation agricultural reached its zenith of refinement. Developing, maintaining, and sustaining a viable agricultural system in one of the world's driest deserts is no small feat for humankind. Compounding the constant adversities of desert and highland living, such as lack of rainfall, heavy frosts, and hypoxia, are the stochastic stresses of earthquakes, volcanic eruptions, tectonic uplift, and El Niño deluges.

Living under such conditions with a myriad of uncertainties, humans usually create some type of religion to help explain unnatural occurrences, to validate the controlling forces in the Cosmos and ancestral spirits, and to reinforce humans' ability to cope with their own frailties (Keesing 1981). Thus, Prehistoric Peruvians conceptualized and created a religion rife with gods which supposedly controlled the rain, springs and rivers, and huacas which could be venerated in the many oracle centers built as homes for these special ethereal entities. All this human energy was expended in a vain effort to forestall the inevitable calamities which occur sporadically in many locations of Peru.

The people hoped that this religion could assuage the hurt and torment which must follow each catastrophe, for undoubtedly, death and debilitation from natural calamities have been constant companions of the Peruvians since they first settled along the coast and in the highlands of their native land. Developing a native risk management system which entailed growing many native

domesticates on terraces in different ecological zones, sharing food stuffs and other life-sustaining necessities with their ayllu members, and developing an equitable water management strategy, ancient Andeans enjoyed a better diet than does the modern population of Peru. Combining camelid pastoralism with a highly sophisticated irrigation technology, second to none on our planet, prehistoric Peruvians did a masterful job of surmounting the vagaries of their environment.

Incorporating data from previous flood studies has allowed me to more fully understand and interpret the sometimes confusing archaeological record encountered during the course of my investigations. Although the general preservation in Peru of many cultural materials, such as ceramics, textiles, and botanical remains is much better than in many other areas, and the preservation of human remains is exceptional, the flood record is sometimes biased toward the more spectacular, gargantuan flood events because of differential preservation. Some time will probably pass before future investigators can fully delineate and definitively date the two major flood events, Chuza and Miraflores, whose deposits are found in the flood record throughout the Ilo Valley and the neighboring coastal quebradas, including Carrizal, Miraflores, and Pocoma. Hopefully I will be able to play some small role in the continuing archaeological efforts to unravel the mystery of the fascinating archaeology of Peru.

CHAPTER 4
METHODS

Introduction

The methods utilized during the course of this investigation included a number of common archaeological and geoarchaeological techniques which allowed this investigator to obtain the maximum amount of information about fairly large, widely separated geographical areas in the shortest possible time. Investigations in 1990, 1991, and 1992 involved: 1) Using a field survey to search for potential sites and to ascertain the extent of flood damage done to occupational and agricultural areas in the Ilo Valley and in the coastal quebradas; 2) Excavating units (one by one meter pits) in occupational and agricultural terraces, and, occasionally, in irrigation canals; 3) Cleaning and drawing profiles of flood deposits and drawing cross-sections of irrigation canals; 4) Mapping units, trenches, and geologic columns; 5) Processing and analyzing of artifacts in the laboratory; 6) Searching for and collecting carbon or vegetal debris for the future ^{14}C dating of occupations and of flood events when funds become available to do so; and 7) Making computer maps, profiles, and illustrations from the detailed drawings made in the field.

Field Survey

Preliminary investigations began in the summer of 1990, when the author spent most of the time studying the flood impact on the irrigated agricultural system built by the Chiribaya Culture apparently sometime around 1000 A.D. (Moseley et al. 1992). Much of the time was devoted to pedestrian survey, (and sometimes "windshield survey" from a 4-wheel drive Toyota), of the entire length of the 9 km-long canal system (Figure 4-1), assessing the damages and looking for potential sites for profiling and excavating. It was obvious that the flood debris from the lateral quebradas had severely damaged the whole canal system by covering the agricultural terraces and the main irrigation canal along the entire extent of the system. Overbank sediments also covered the lower agricultural areas at Planting Surfaces 1 and 2 (#236 and #215, respectively, as designated by Owen 1991), which lie 3-5 meters above the flood plain. Since digging permits were unavailable for this area, excavations were limited to some shovel testing and very small probes using only a trowel. During the field season, some time was also spent doing a preliminary survey of the coastal quebradas.

Because the 1991 season (July) in Peru was brief, emphasis was placed on the recovery of carbon from the flood deposits for dating purposes and conducting some additional surveys of the Ilo Valley. Supplemental surveys of the coastal quebradas were conducted in an effort to determine which of these locations would provide the best comparative data that could be used to reconstruct the most complete scenario of the prehistoric flood. Further, these

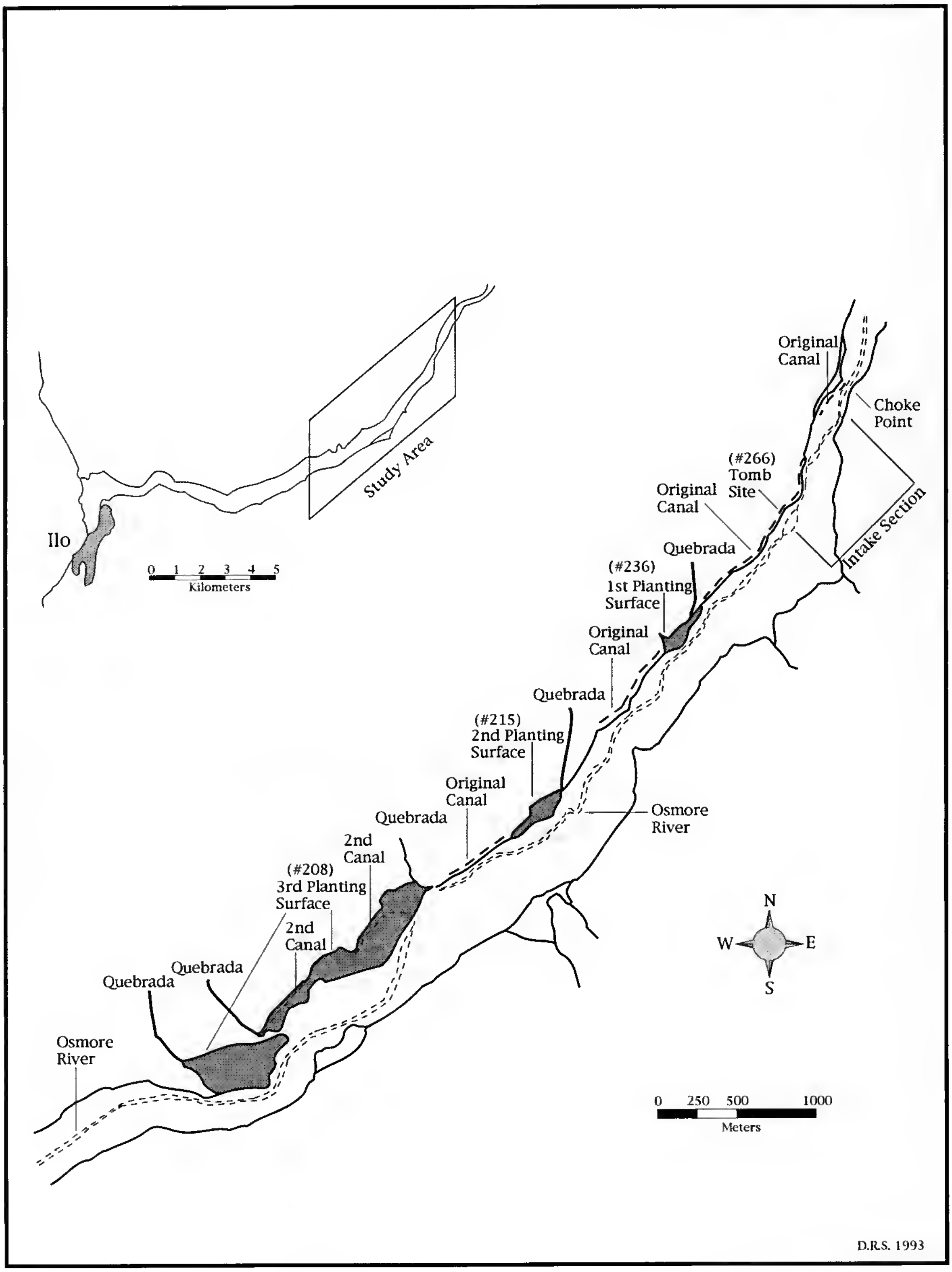


Figure 4-1: Ilo Valley--Lower Osmore Drainage

data would hopefully shed some light on what happened to the Chiribaya Culture during and shortly after the Miraflores Flood.

In 1992, I once again returned to Peru to devote the whole summer (June to August) to the investigation of the three quebradas which I had chosen as the best locations to test my hypothesis that the Miraflores Flood had ultimately led to the demise of the Chiribaya Culture. In addition to excavating, much time was consumed doing pedestrian survey of the upper reaches of the individual quebradas looking for canal remnants, agricultural surfaces, cultural remains, and flood debris.

Unit Excavations

Unit excavations were conducted using the same methods at each location. Most test units, measuring one meter square, (1 x 1 meter) were oriented on a North/South axis and strung with nylon string secured at each corner of the unit with a large spike. Excavating was done using arbitrary 10 cm levels, and all sand and dirt was sifted through a screen with 1/4 inch hardware cloth. Since most of the flood deposits were highly compacted because of high sea-salt content from the ocean fogs and breezes, the dirt had to be excavated using a pick and then broken apart before screening. Recovered materials that were durable items were bagged and labeled for later cleaning and identification in the field laboratory in Ilo. Other delicate items, such as textiles and botanical remains, were wrapped in aluminum foil to enhance preservation.

When possible in locations where several unit were required because of spatial relationships, all units were oriented along a transect using a magnetic heading of NNW (330°) or due West (270°) starting from a datum point. The purpose of this technique is to make the location of excavated units easily accessible to future investigators. Such units were utilized when excavating domestic terraces, agricultural terraces, and, in a few cases, irrigation canals.

Spacing of the units depended upon the size of the area under investigation. For example, at the Miraflores Quebrada, one meter square units were placed on five meter centers between the two large, sunken, quadrangular features, (6 x 8 m and 8 x 10 m, respectively). This method allowed the investigator to cover as much of the occupation area as possible without missing too many important diagnostic materials.

Trenches

Since the prehistoric irrigation canals usually have an outer, mortarless stone-faced retaining wall, a narrow trench, about 30 cm wide, proved to be the most effective method of excavating these structures. Such trenches rarely need be more than 40-50 cm in depth in order to reveal the stratigraphy of the canal. Figure 4-2 is the profile drawing of the trench cut through the #2 High Canal at the Pocoma Quebrada, and it shows the aeolian surface sand and dust, the 1982-83 El Niño deposits, and the contour of a possible Spanish Colonial canal (heavier line) cut into the Chuza deposits, which overlie the Miraflores sheet wash. Apparently, after the

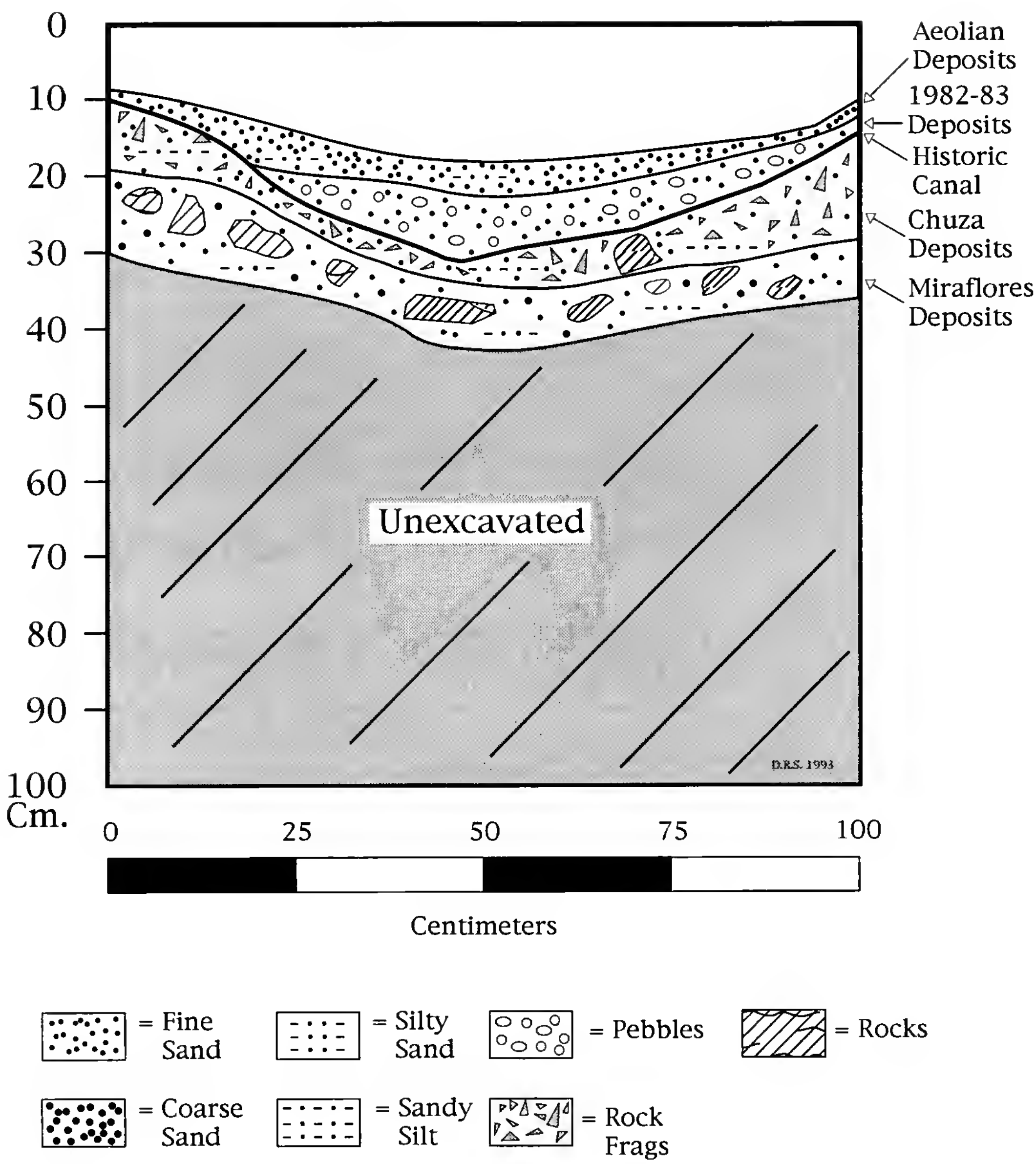


Figure 4-2: #2 High Canal--North Side of Pocoma Quebrada

1607 A.D. Chuza Event filled the colonial canal, the tenders of the olive groves carved out a new irrigation canal in an effort to salvage their trees growing on the north side of the quebrada.

Figure 4-3 is the profile drawing of a trench in the #1 Low Canal also at Pocoma Quebrada, which had remnants of two canals on both the north and south sides. This profile reveals that once again a new canal channel was dug into the Chuza Flood deposits, but this time the inner Chuza materials have been entirely removed, using instead the compacted Miraflores materials as the inner canal wall. Because of the depth of this canal, the 1982-83 El Niño sheet wash is more substantial than in Figure 4-2. The canal shown in Figure 4-3 apparently fed a different section of the colonial groves since it turns South from its westerly course toward the modern olive groves.

Shovel Testing

Shovel testing provides the archaeologist with a method which can be used for quick sampling of large areas, such as the domestic surfaces and, especially, the agricultural surfaces. Utilizing this method, the investigator often can promptly identify any meaningful cultural areas or agricultural surfaces. Further, the researcher can possibly determine what agricultural activity transpired prehistorically, both pre- and post-flood, and whether the planting surfaces were later used by the Spanish Colonialists and/or by modern farmers. Such shovel testing also allows the rapid recovery and identification of the agricultural crops which were grown.

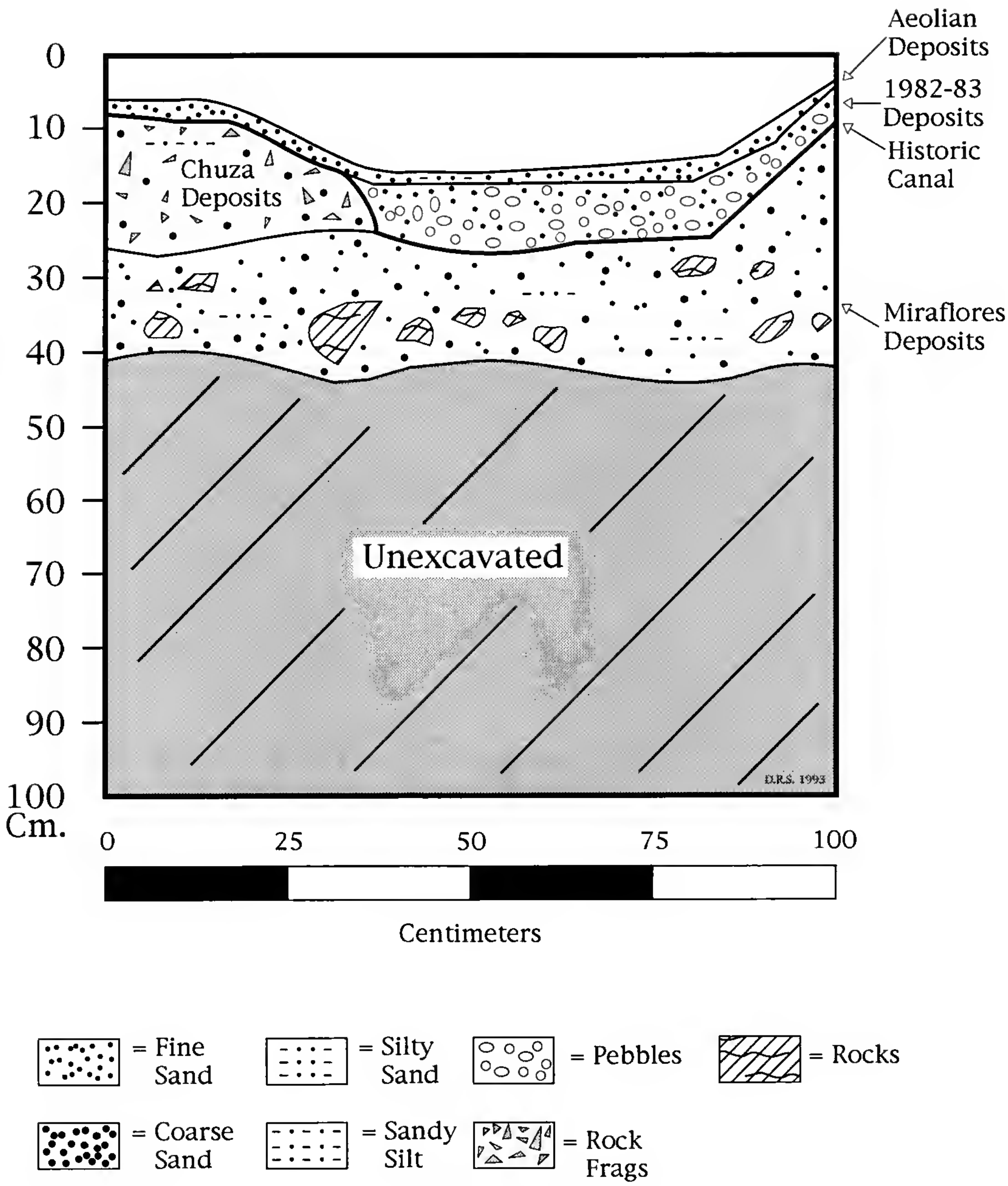


Figure 4-3: #1 Low Canal--South Side of Pocoma Quebrada

Because of the lack of field assistants and the time constraints of the 1992 field season (May through July), shovel testing was utilized in a number of locations in the coastal quebradas of Carrizal, Miraflores, and Pocoma. Usually profile drawings were not made of such probes, but, nonetheless, a careful written record was always made of any positive (cultural remains) or negative (no remains) evidence.

Unit Profiles and Floor Plans

After excavation was completed, the east wall of each unit was brushed clean, and the natural strata were delineated by incising with a trowel between the different strata. Each stratum was accurately mapped by taking vertical depth readings every 10 cm along a level, horizontal reference string. After depth readings were completed, color slide photographs were taken of each unit profile. After the profile drawings were made and their analysis completed, the unit was back-filled.

When something unusual or diagnostic was found included in the bottom of a unit, a floor plan was drawn. Figure 4-4 is a floor plan from one of several units dug between the rectangular, sunken features at the Miraflores Quebrada. The floor plan shows a 60 + cm boulder which was moved by the Miraflores Flood and covered by almost 90 cm of flood deposits. The size and position of this large rock is a good indication of the force of the Miraflores Event because the Chuza Event, which was a sizable surge, rarely if ever moved rocks of this size.

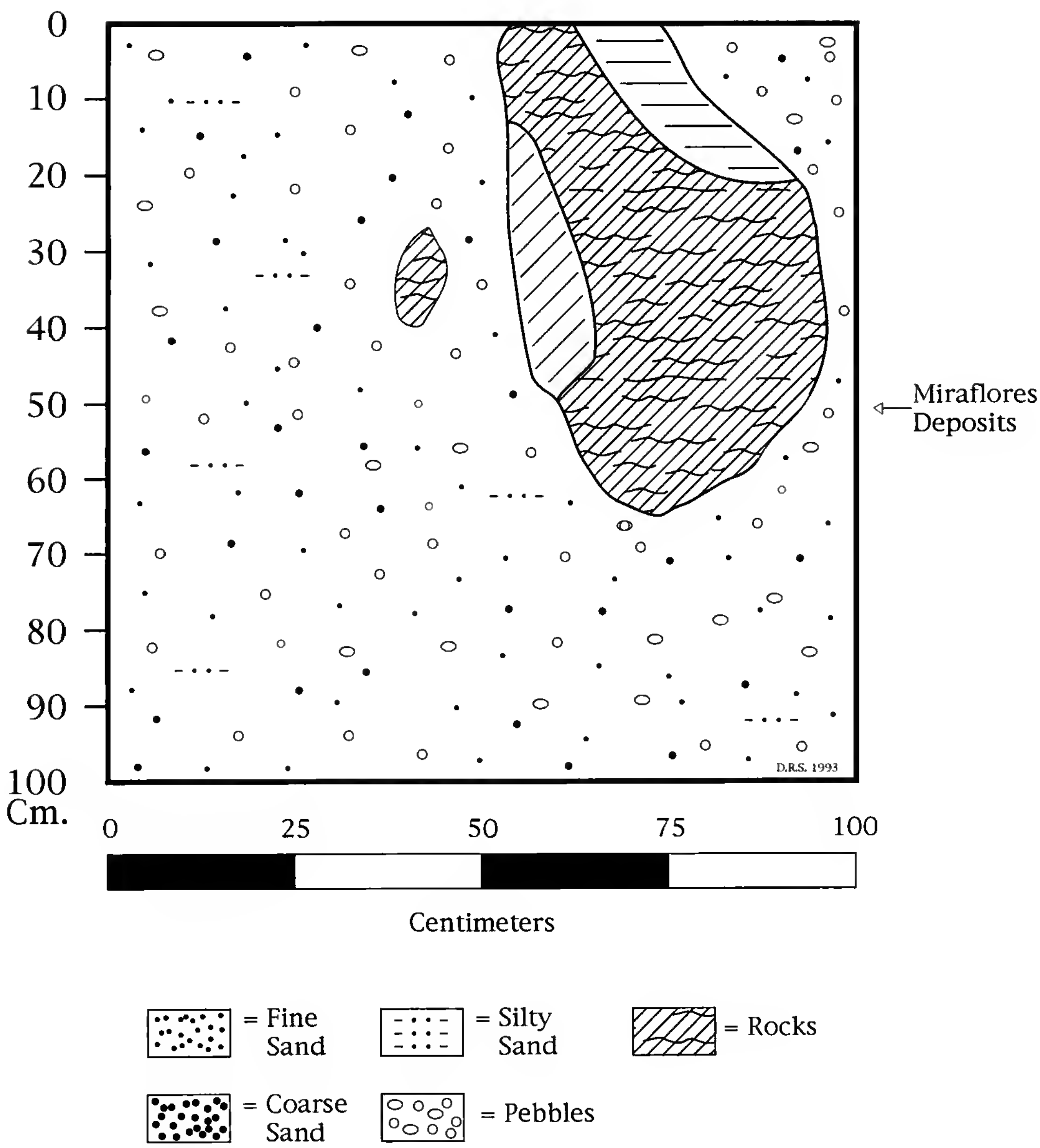


Figure 4-4: Floor Plan of Unit #3 N. at Miraflores Quebrada

Quebrada Geologic Columns

Since quebradas serve as major collection points for all runoff from the highlands as well as the middle elevations and the lower coastal plains, useful overbank flood profiles are usually found along one or both side walls of the deeply incised main quebrada channels and along the smaller lateral branches feeding into these channels. Flood deposits from the wet El Niño periods and deposits from the dry aeolian interludes are usually well-preserved and normally provide an uninterrupted record of both the modern and the prehistoric climatological regimes from far-southern Peru. Volcanic ash from the Huayna Putina volcanic eruption in 1600 A.D. is often intersticed between the two flood episodes, and, thus serves as a ubiquitous, accurate chronological marker separating the two flood episodes.

Quebrada profiles were made by cleaning a one meter wide column, extending from the surface to the bottom of the quebrada channel wall. Vertical and horizontal measurements of the different strata were referenced from a level control line strung across the top of each column. All measurements were recorded on graph paper for later use in creating a computer illustration of each profile.

Figure 4-5, for example, is a typical geoarchaeological column from the upper Miraflores Quebrada that shows the distinctive sequence of events found throughout the investigated quebradas. Since the 1992 El Niño was a minor event, its sediments are only found in the very bottom of the quebradas and are not visible in the profile. This figure shows an aeolian episode separating the

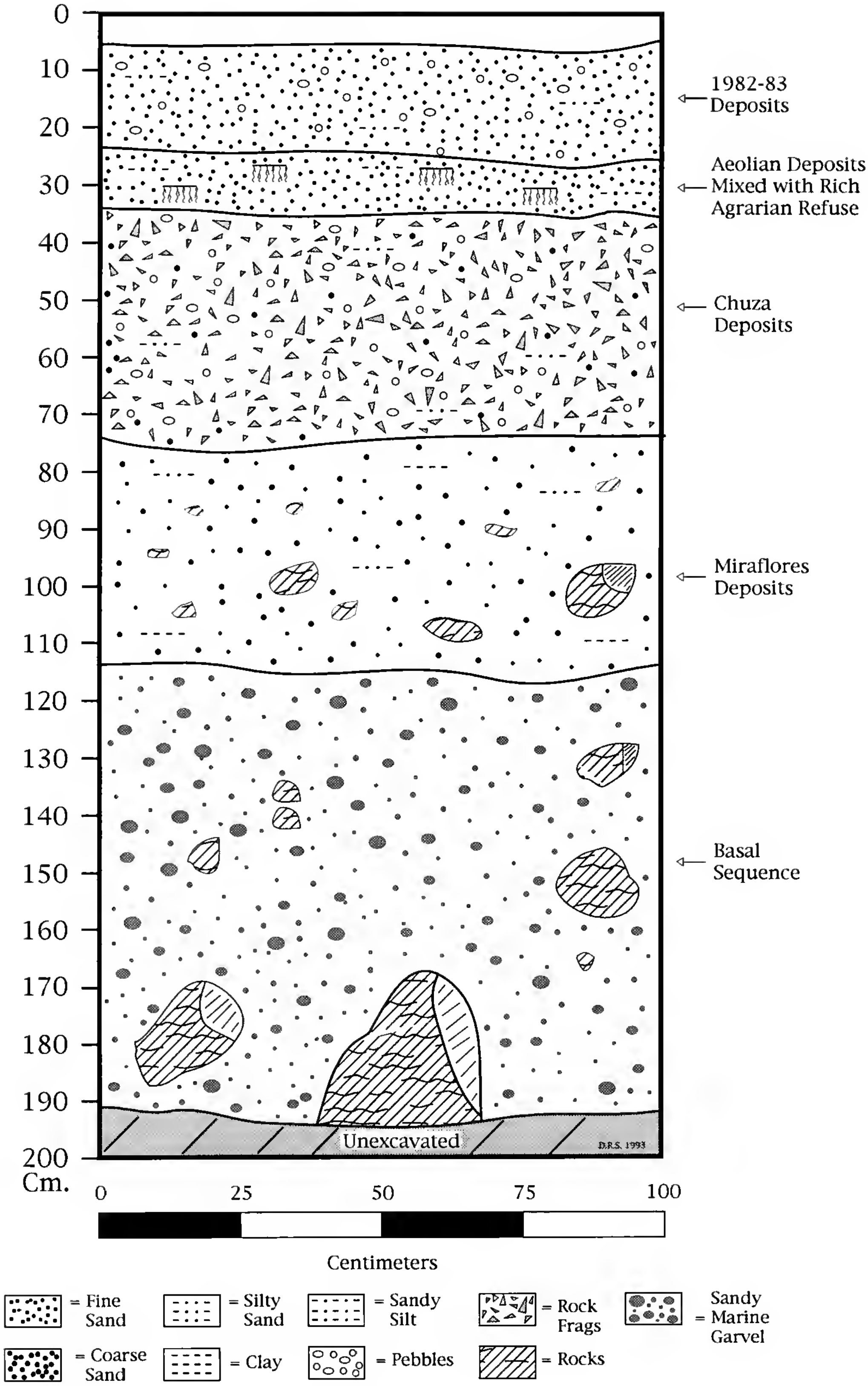


Figure 4-5: Geologic Column #2 at Miraflores Quebrada

1982-83 and the Chuza deposits. Since this column was taken downslope from the prehistoric and historic agricultural terraces, there is rich agrarian refuse mixed with the fine sands of the aeolian layer. The characteristic Miraflores sediments are seen overlying the Basal Sequence, whose events have yet to be identified or separated, which is composed mainly of large rocks up to 20 cm in size and an abundance of sandy marine gravels.

Mapping

The location of each unit, shovel test, trench, feature, and profile was recorded in the field for later transfer to a permanent map. Maps were made from aerial photographs obtained both from the Servicio Aerofotografico del Peru and from the actual surveying coordinates taken in the field by a mapping crew. A line map drawing was made from the aerial photos using known reference points, such as roads, road intersections, and permanent structures. Radial displacement, which distorts the ground features on aerial photographs, was lessened by using a Kodak Stereo Transferscope when transfering these features onto mylar (see Avery and Berlin 1985 and Lillesand and Keefer 1987 for more information on the use and interpretation of aerial photography). Plotting the location of the various units on a master map was facilitated by the fact that the units were excavated on 5, 10, or 15 meter centers and along a known magnetic compass heading.

Laboratory Analysis

Recovered materials from the field were brought back to the laboratory in Ilo where, when possible, they were washed, placed on screens, and allowed to dry in the sun. This procedure was permissible when working with sturdy materials, such as bone or ceramics, but it was impossible when dealing with delicate textile fragments. Dirt and debris, which adhered to these fragile materials, were gently brushed away using small, soft-bristled brushes. Organic remains, such as wild and domesticated plant refuse, were treated in a similar manner. Plant fibers and animal hair were left uncleaned and identified, when possible, using a binocular microscope with a self-contained incandescent light source. Although the recovered cultural remains were scant, care was taken to identify and to record each small piece.

Recovery of Carbon

The search for carbon, which could be used in ^{14}C dating, was almost a futile endeavor because of the inherent characteristics of the Miraflores Flood. Field investigations revealed that one characteristic of this flood is that the volume and speed of the flood surge tended to push cultural materials ahead of the mudflow, removing most of them from the landscape, rather than including items such as pottery sherds and botanical remains in the flood sediments. The second quality of the flood is that it was an extremely wet event, which facilitated the decomposition of most vegetal matter. Therefore, because of these two aspects, it was extremely difficult to recover any carbon or plant remains for ^{14}C

dating of the Miraflores Event. However, on those rare occasions when some carbon was found, recovery was done with tweezers to avoid contamination from the oil and other foreign matter carried on the hands of the investigators. Carbon was then transferred into an envelope shaped from aluminum foil and carefully sealed for later transport.

Computer Methods

Creating Computer Maps, Profiles, and Illustrations

The process for creating publishable quality maps, profile drawings, and illustrations with a computer is similar for each example. Sometimes an original map can be scanned, digitized, and stored directly onto the hard drive of a computer, using a high quality scanner with a resolution of 300 DPI (dots per inch) or greater, if available. Because of memory constraints, smaller, less expensive, and slower personal computers will not store or process digitized images. More often than not, a line drawing of the meaningful features from a map must first be carefully traced by hand and then scanned into the computer. Drawings for this dissertation were scanned using a high resolution (800 DPI) B & W/Color scanner.

After images are scanned, they must be processed to reduce the inordinately large memory requirements. For example, a scanned 8" x 10" B & W photograph will produce a digital image of 4-5 Megabytes (Mb). A complex line drawing can require as much as 300-400 Kilobytes (Kb). Therefore, the size of the scanned image

file must be substantially reduced because most computers used today in academia do not have large enough RAMs (Random Access Memories) to function properly when processing such large files. However, processing the scanned image, using a "streamlining" program, eliminates extraneous pixels in a line drawing by creating a new, narrower centerline which faithfully follows the center of each scanned line. The result is a new image file that is now 40-50 Kilobytes in size, which can easily be stored and manipulated by the computer. An added benefit is the fact that the digital file is easily transportable on one 3.5" diskette; whereas, an unprocessed digital image must remain on the computer's hard disk drive.

The image is now ready for any additions, such as descriptive text, shading, highlighting, and new features, or deleting unwanted features or lines. This author has worked with a number of CAD (Computer Aided Design) drawing programs and has found, for his purposes, the Adobe Illustrator program to be the most useful for making maps and illustrations of field drawings. This specific program is not easily mastered, but once it is, there is virtually nothing the user cannot draw in two dimensions. Once again, the memory requirements for this program are fairly large. Nominally, a computer needs 4 Mb of RAM or more to run efficiently certain types of illustrating software. My personal computer, with which all illustrations for this dissertation were made, has 20 Mb of RAM, which allows the computer to run quickly and effectively without any system failures or any irritating pauses while the computer searches for additional free memory. Undoubtedly in the near

future, memory requirements will become even larger as more "memory-hungry" applications are developed.

Since the finished illustrations demand the highest resolution for publication, they must necessarily be printed on a high quality laser printer. A laser printer, with a resolution of 600 DPI, was used to print all the illustrations used in the dissertation. Here again memory plays an important role. Without sufficient RAM, a illustration such as Figure 4-1 cannot be printed because the printer does not have enough storage to hold simultaneously the fonts, digitized lines, and shading requirements. For the moment, my personal laser printer readily handles such requirements because of its large internal RAM and its high speed processor.

Producing a Three Dimensional Model of the Ilo Valley

Figure 4-6 is a photograph of a three dimensional model of the Ilo Valley, which includes: 1) the active and abandoned modern agricultural surfaces; 2) the abandoned prehistoric settlements; and 3) prehistoric agricultural terraces, and as well as the topography of the valley and its floodplain. A number of steps were required to complete the finished image. A base map was created using a pair of aerial stereo photos at a 1:10,000 scale. Although it cannot be totally eliminated, photographic distortion from radial displacement was lessened by using a Kodak Stereo Transferscope. Using ground controls, such as road intersections and buildings, identifiable on both the photographs and a Peruvian Agrarian Reform base map, it was possible to create a final map which had a spatial accuracy sufficient for most archaeological field work.

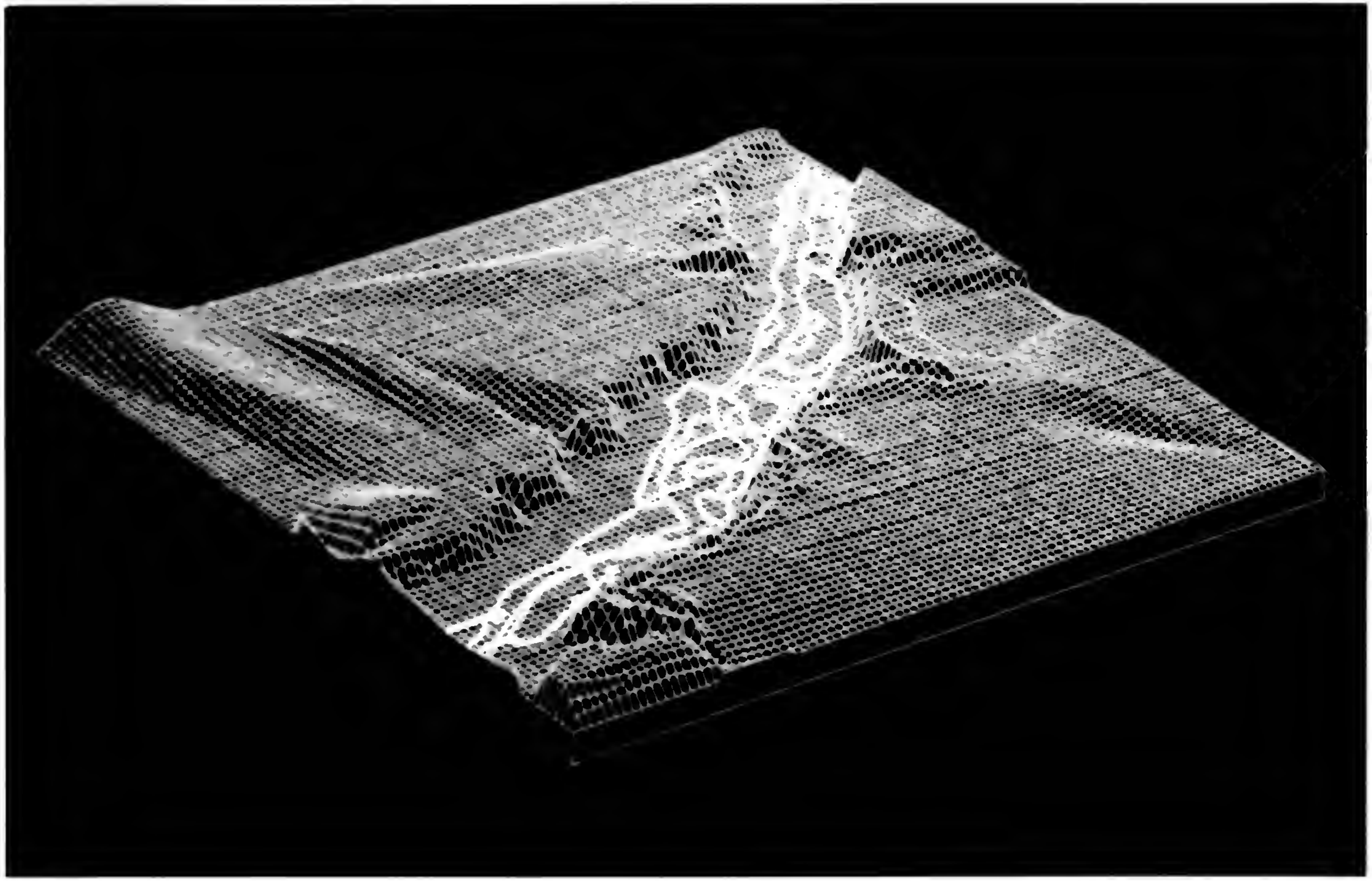


Figure 4-6: Three Dimensional Model of the Ilo Valley

Obviously, such a map would not have the high spatial accuracy which can now be achieved using a GPS (Global Positioning System) receiver. Only orthorectified photos, which have eliminated both the radial and relief displacement (caused by the differences in altitude of the ground features and the airplane from which the photos were taken), can be used to create an accurate map of an area. Distances, angles, and areas can be measured directly from orthophotos (Lillesand and Kiefer 1987), but since it is so expensive to have them produced for field work, orthophotos are beyond the budget of most graduate students and professors of archaeology.

A mylar drawing was made of pertinent cultural and geographical features (Satterlee 1990). This drawing was hand digitized, using a CalComp 9000 digitizing board, into the ARCINFO GIS (Geographical Information System) software developed by ESRI (Environmental Systems Research Institute, Redlands, California), and stored on the hard disk drive of a XIT-IBM Workstation. The topographical lines from a 1:10,000 scale 1973 Agrarian Reform map from Peru were hand digitized using the same process as described above.

A "G.I.S" is actually a computer software program which allows the user to automate, manipulate, analyze, and display geographical data in digital form (ESRI 1984). Geographical information is stored as Cartesian X,Y coordinates, which allows the computer to form ARCS (lines) and POLYGONS (shapes) of a particular area. Information concerning area, usage, artifactual

materials, or cultural affiliation is stored in an attribute table assigned to each polygon. Color coding can be added to facilitate identification of the different cultural areas.

Once both images, known as "coverages," were safely stored in the computer's memory, one coverage was then overlaid--merged--on top of the other. This type of overlay is created by a mathematical process that orients both coverages so that the known ground control points, such as road intersections, domestic structures, Spanish Colonial walls, and canals, that exist in the layers of both coverages, will perfectly align with each other. The elevation for each topo line had to be entered into the relational data base of the ARCINFO program so that the information could be used to create the final 3-D view of the valley, which was produced by the TIN (Triangular Integrated Network) module of the ARCINFO program [For a more detailed discussion of making digitized maps of archaeological sites, see Scott et al. 1991].

The final step was to add the two dimensional cultural and geographical features of the valley from the base map to the 3-D rendering. The outlines of these features were also digitized and stored using ARCINFO. Once the 3-D rendering is completed, the two dimensional features, which are stored as a third coverage, are "draped," that is "overlaid," accurately onto the 3-D valley view. The finished product and its accompanying data base can be used to calculate and to demonstrate the loss of agricultural land through time (Satterlee 1992), to compare the difference in total agricultural area for historical and prehistorical periods, or a myriad of other comparisons which are limited only by the user's imagination.

Discussion

The methods outlined here all provided similar information concerning both the historical Chuza Flood and the prehistoric Miraflores Flood. The quebrada profiles clearly show the deposits from two major flood events, which have occurred in the last 500-600 years in the study area. Occasionally, cultural remains, such as pottery sherds or bone, are seen protruding from the Chuza deposits in the quebrada channels, but very few cultural remains from the Chiribaya Culture or vegetal matter were observed within the Miraflores deposits in any of the three coastal quebradas. However, some mud casts of cane (*Caña brava)* and of a few roots can be found, in isolated places, included in the Miraflores deposits near the Tomb Site (#266) in the upper Ilo Valley (Figure 4-1). The presence of only the mud casts with no physical remains, strongly suggests that the Miraflores Flood was an extremely wet event that promoted the rapid decomposition of vegetal matter.

Although the shovel tests could not be excavated too deeply, they, nevertheless, allowed the investigator to expose the flood deposits from the two separate events, to analyze each flood's composition, and to search for included cultural or vegetal materials. The shovel tests yielded results similar to those of the unit excavations. Cultural refuse was often included in the Chuza deposits; whereas, the Miraflores deposits were customarily devoid of any non-flood materials. These observations also lead to a like conclusion concerning the characteristics of the Miraflores Flood--It

was a very wet, strong event which was typically not conducive to the preservation of materials.

Unit excavations at the coastal quebradas, ordinarily, did not reveal a layer of volcanic ash from the eruption of Huayna Putina separating the two floods. Possibly the speed and moisture content of the Chuza Flood were such that its mudflow either swept away all ash or the ash was diluted and incorporated into the finer flood sediments. An exception was the 2 x 2 m test probe placed in the east wall of one sunken feature at Miraflores Quebrada. Here a 2-3 cm layer of tephra delineates the two events. Profiles of overbank deposits in the Ilo Valley sometimes also disclose the Huayna Putina ash layer between the Chuza and Miraflores sediments. Another possible explanation for the absence of the H. P. ash separating the two flood events at a number of locations is the fact that there was an enormous tidal wave in 1604 A.D. (Cobo 1890), which adversely affected the coastline at Ilo. This tidal wave could have readily washed away all traces of the volcanic ash at any location which the Tsunami reached. H. P. ash is often found *in situ* in the upper Ilo Valley which was beyond the extent of the tidal wave, but the volcanic ash is often absent in the lower valley and in the low-lying coastal quebradas which were probably affected by the tidal wave.

Laboratory analysis of the recovered remains demonstrated that the number of sherds and the amount of other materials, such as bone, botanical remains, and fibers, were substantially greater from the Chuza stratum than from the Miraflores stratum (see Chapter 6 for artifactual categories and frequencies). Further, the

meager remains from the Miraflores Flood were often significantly abraded so as to make them sometimes nearly unidentifiable as to their parent culture. On the other hand, the remains from the Chuza Flood were only slightly abraded, even though the flood matrix is composed of hundreds of fairly sharp, angular rock fragments. Again one must draw the conclusion that the Miraflores Event was a especially wet, swift mudflow. Although it cannot be definitively proven at this stage of investigation, the facts seem to indicate that while the Miraflores Event tumbled and scoured the sherds, it also annihilated any Chiribaya people who were occupying the Miraflores Quebrada at the time the flood transpired.

CHAPTER 5
SITE EXCAVATIONS

Introduction

Site excavations are perhaps some of the most important aspects of an archaeologist's field work, since it is the excavated data that permit him to interpret and to synthesize various kinds of information into an integrated cultural scenario for the particular time period and specific location which is being investigated. Therefore, it should be with the utmost care that the researcher chooses the locations for the units and the profiles he plans to excavate; however, this is not often an easy decision. The following aspects of my field investigations pertaining to site excavations will be discussed: 1) Criteria for choosing unit and profile locations; 2) Location and description of units, profiles, and trenches; 3) Indications of the severity of the prehistoric Miraflores Flood and the later historic Chuza Flood from these excavations; and 4) Evidence in the archaeological record for the survival or demise of the Chiribaya Culture following the Miraflores Flood. Only those units and geologic columns for which no field drawings were made will be discussed in this chapter. Drawings of the remaining units and geologic columns, which were of special interest, will be discussed in Chapter 7 (Profiles and Geologic Columns).

Choosing the Locations of Units

Carrizal Quebrada

Choosing the location for individual units at the Carrizal Quebrada was a challenging task for several reasons. Unlike the Miraflores Quebrada which has a broad, relatively flat coastal plain, the topography at Carrizal is undulating with the relief varying as the landscape alternates between hills and swales on both sides of the main quebrada channel, as shown in the aerial photograph in Figure 5-1. Therefore, the flood damage could vary from one specific elevation to another. For example, since many of the prehistoric domestic areas are located at the higher elevations, they could have been left unscathed by the floods; whereas the prehistoric irrigation canals and the terraces which they watered, were located either in the low-lying areas between the domestic areas or below them, and, thus, would be more directly and seriously affected by the same floods. Since one prehistoric canal is located about a kilometer farther East (upslope) from these areas, the flood impact on this canal should be more extreme since any mudflows would have buried this canal before reaching the lower-lying areas.

To further complicate the process of choosing the optimum locations for excavation, there were some large colonial canals (Figure 5-2A) interspersed among their prehistoric counterparts (2B). Fortunately, the construction techniques for the two canal systems are quite different. The main canal and some of the lateral feeder canals for the Spanish Colonial irrigation system often have stone-lined side walls, but the colonial canals at Carrizal always have

Figure 5-1: Aerial View of Carrizal Quebrada

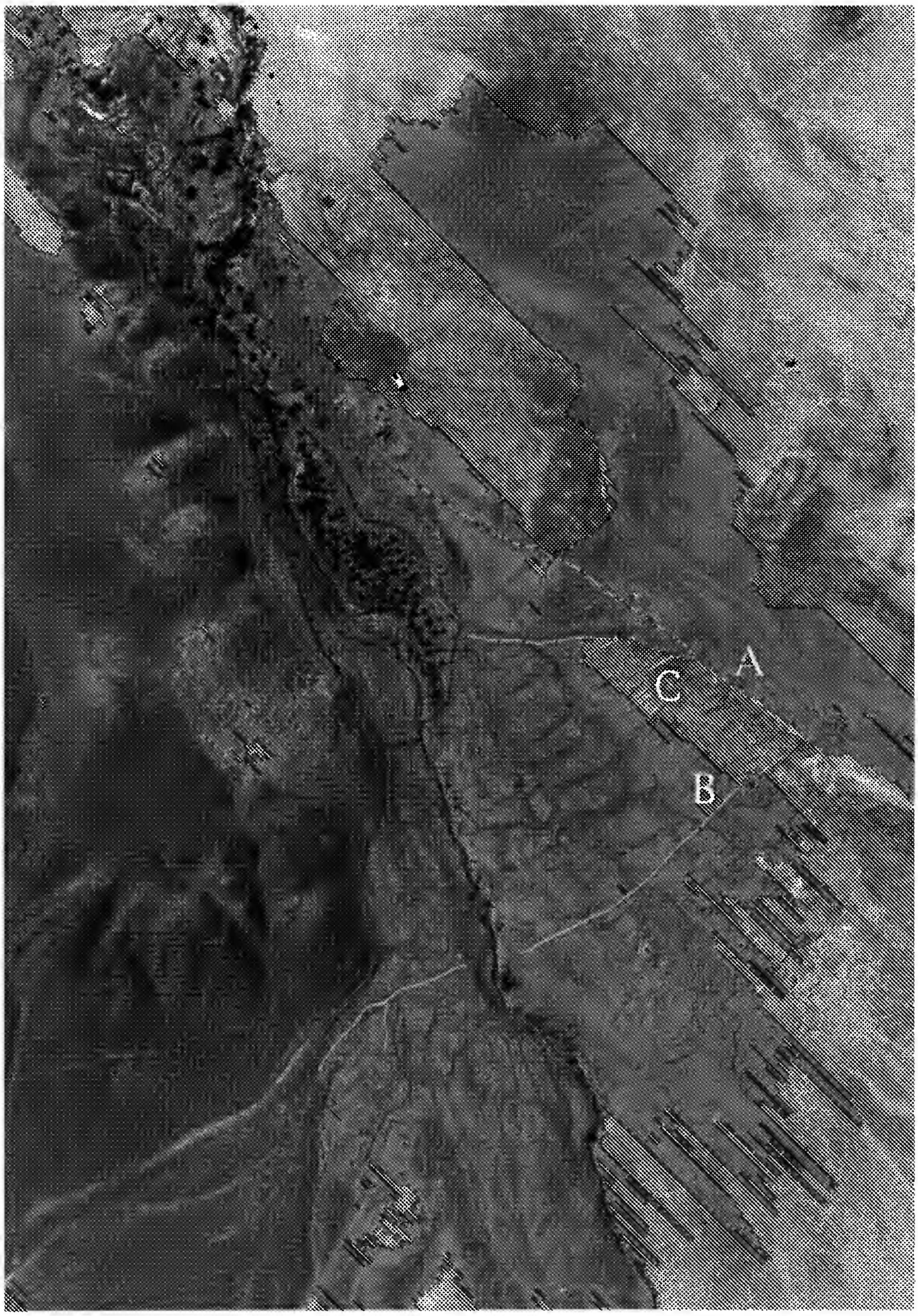


Figure 5-2: Aerial View of Carrizal Quebrada

stone-lined bottoms--a technique introduced in colonial times, which continues to be used today. Even a few of the smaller branching canals also have stone-lined side walls (Figure 5-2C). Contrasting with this colonial construction style is the Chiribaya practice of building canals without stone-lined walls and perhaps using the natural stratum for the canal bottoms, though there are some stoned-lined prehistoric canals found at higher elevations of the Moquegua Drainage (Stanish 1987, 1992).

In addition to these considerations, the final decision of where to locate the units was based on a combination of other significant factors. The North-to-South segment of the prehistoric canal, running perpendicular to the flood's flow, was chosen as a likely place where the flood surge could have done considerable damage to the canal, and, at the same time, the flood deposits should have conceivably collected in the bottom of the canal channel. Because of the difference in elevation, the lowest areas lie directly in the path where the mudflow was most likely to have run and consequently should have the deepest flood deposits. Further, the canals could contain evidence from both the historical and prehistorical events superimposed upon each other. Excavating units farther down the 6-7° slope at Carrizal (Figure 5-3), in the direction of the Pacific Ocean, would possibly reveal the farthest extent of the Chuza Flood.

Few units were excavated on the domestic surfaces at Carrizal since the main purpose of this study was to determine the flood impact on the prehistoric, irrigated agricultural system of the Chiribaya. Furthermore, a small number of the tombs in the domestic areas were being excavated by a University of New Mexico

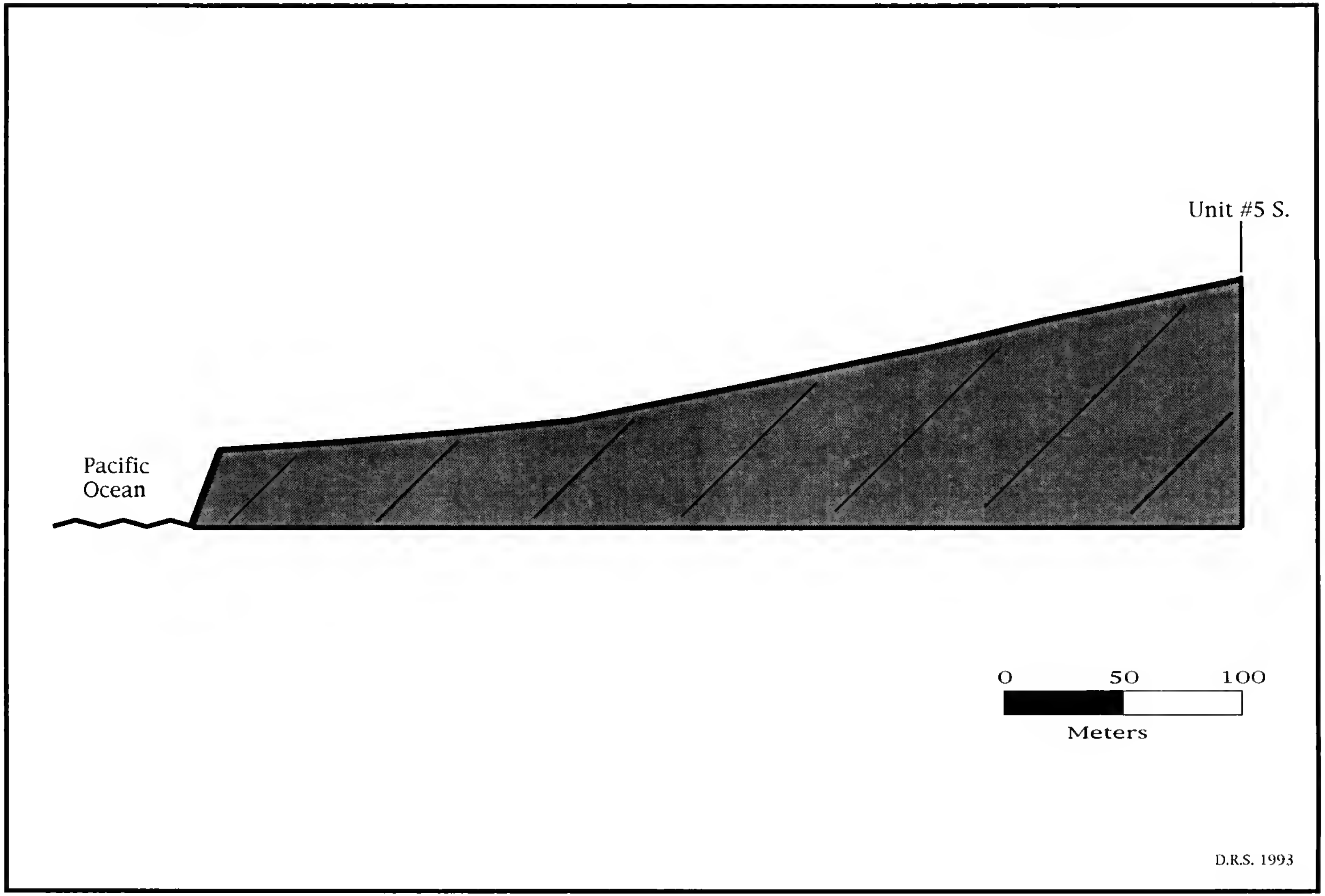


Figure 5-3: Profile of Carrizal Quebrada

(UNM) graduate student who would consult with me concerning the flood stratigraphy whenever he encountered flood deposits in any of his units. Therefore, I had an opportunity to identify the flood deposits and to assess the damages in the higher areas, and to compare them to the sediments which I had discovered in the lower-lying portions of Carrizal.

Miraflores Quebrada

In addition to the criteria discussed above, the location for some of the one meter square units at the Miraflores Quebrada was determined by the fact that there were undisturbed domestic terraces with two rather large sunken features at this site. This area would be the most logical place to begin excavating because this zone could be where much of the concentrated human activity transpired and, consequently, where the most artifactual evidence would likely be found. The decision to excavate units at Miraflores Quebrada along a transect that ended at the edge of the lower quaternary marine terrace was based on the fact that aerial photography indicated that the Miraflores mudflow covered this terrace and only ceased its forward motion when the flood reached the Pacific Ocean (Figure 5-4). Further, excavating at the extreme edge of the marine terrace would allow the comparison of the depth of the Miraflores flood deposits here and also at the sunken features, ca. 430 meters farther upslope. Using this strategy of excavating along a transect, one should also be able to discover the farthest extent of the 1607 A.D. Chuza Event. Comparing the depth of the different flood deposits found in the various units with those deposits found at the

Figure 5-4: Aerial View of Miraflores Quebrada

farthest extent of the individual floods ought to provide an indication of the relative strengths of the two flood episodes, even though they occurred three and a half centuries apart.

Pocoma Quebrada

Choosing the excavation locations at Pocoma Quebrada was the least difficult because of the quebrada's small size and the fact that there are only two basic areas of interest concerning this investigation. There are prehistoric domestic terraces lying about 30 meters above and 130 meters to the South of the main quebrada channel (Figure 5-5A) and prehistoric agricultural terraces which are located on the north and south side of this same quebrada channel (Figure 5-5B).

Of the three quebradas studied, this quebrada is unique because it has three irrigation canals, a High canal (Figure 5-5C) on the north side of the quebrada and High and Low canals on the south side of the quebrada channel (Figure 5-5D & -5E). Another unique feature at this location is the existence of some small rills cut by the 1982-83 El Niño run-off. More erosion from the 1982-83 event was present here than elsewhere, probably because in some places the slopes are 45°. In addition, a rectangular hole 3 meters deep, apparently made while excavating for road construction "fill" material, provided an exceptionally good geological column that included a number of Chiribaya pottery sherds.

Figure 5-5: Aerial View of Pocoma Quebrada

Excavations at Carrizal Quebrada

Introduction

Originally I had planned to excavate all the prehistoric domestic areas and the agricultural terraces using units dug on five meter "centers," i.e. a distance of 5 meters from the center of one unit to the center of another unit. However, I soon discovered that the flood deposits at the coastal quebradas were almost always very compacted, and that consequently the units would require additional excavation time. On an average day, I was only able to excavate 50-60 cm in one unit in addition to fulfilling my other archaeological duties. Therefore, for brevity's sake, I had to rethink my field strategy and to use "centers" that were sometimes much larger than originally planned.

Location and Descriptions of Units

Figure 5-6 is a general site map of Carrizal Quebrada showing the location of the units, geologic columns, and trenches which were excavated. Additional features of the quebrada shown in Figure 5-6 include: The location of the tombs at 6A that were excavated by UNM graduate student, Rick Reycraft; The olive grove located at 6B upslope from the domestic (6C) and agricultural terraces (6D); and the main quebrada channel located at 6E.

Unit #1 South (U. #1 S.) (discussed in Chapter 7) is located 150 meters northwest of the entrance road to the olive grove (Figure 5-6). The location for this unit was chosen because it sits in the middle

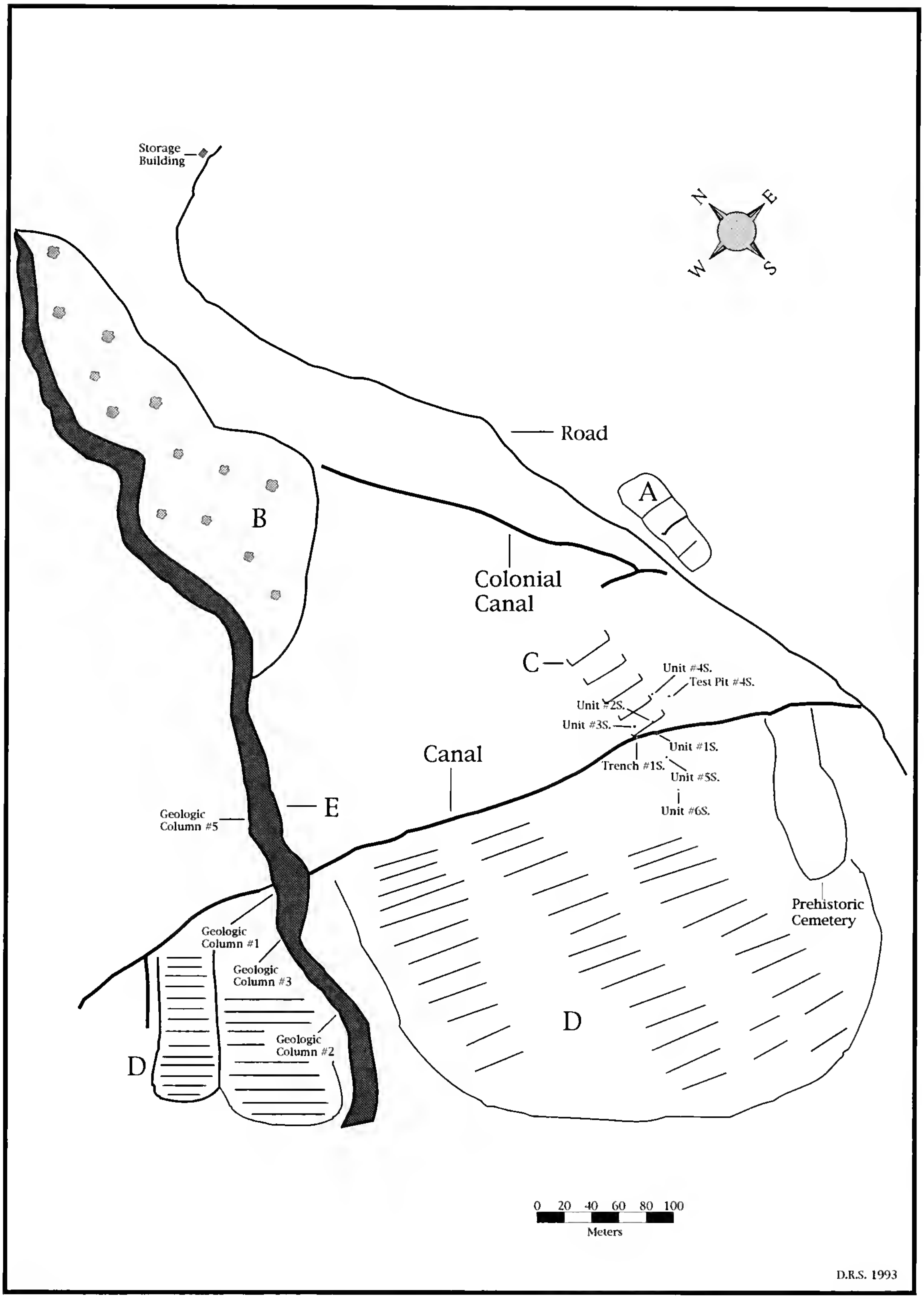


Figure 5-6: Carrizal Quebrada Site Plan

of the largest canal which is the farthest canal downslope from the olive grove in the area known as Carrizal Baja.

Trench #1 South (Tr. #1 S.), located 15 m from U #1 S., is a 40 cm wide probe cut into the canal in an attempt to find the canal bottom and the depth of flood sediments that were deposited closer to the quebrada channel (See Chapter 7).

Unit #2 South (U. #2 S.) is located 5 meters North from U. #1 S. The location for U. #2 S. was chosen because it lies 1.5 m above U. #1 S. in the irrigation canal and adjacent to a domestic terrace. The soils in all units were analyzed using the standardized Munsell Soil Color Charts (Macbeth 1992). A hue notation of a color, e.g. 10YR, indicates its relationship to the colors of (Y)ellow and (R)ed. The numbers following the hue notation, for example, 5/2, indicate the value (5) in the lightness of the soil and the chroma (2) indicates the strength of the color or a departure from a neutral of the same lightness. For example, a chroma notation of an (8) would indicate a soil color that contains more yellow.

This unit had an 18 cm aeolian stratum of grayish brown (10YR 5/2) fine silt with a small amount of fine sand, which overlies unusual burned deposits. Both U. #2 S. and U. #1 S. revealed a 20 cm thick, dark gray (10 YR 4/1) burned layer containing many shell fragments and silty sand. This stratum is too unconsolidated to have been deposited by flood waters, but it is possible that the residue is caused by the burning of Spanish Colonial olive leaves and other agricultural refuse. Directly below this burned stratum was a

yellowish brown (10YR 5/4) layer, at least 40 cm thick, of only sand and a copious amount of gravels with rocks from 8 to 26 cm in diameter.

Unit #3 South (U. #3 S.) is located on the domestic terrace 10 m NNW U. #2 S. (Figure 5-6). Although Chuza is present in U. #1 S. and in the lower area immediately to the South of this domestic terrace, the evidence from this unit and U. #2 S. suggests that the Chuza Flood surge was unable to overcome the additional 1.5 m elevation of the domestic terrace and, therefore, left no deposits on the domestic terrace. The domestic terrace must have been an obstacle for the Miraflores Flood as well, since there was no evidence of the Miraflores Flood found in either U. #2 S. or U. #3 S.

The strata found in this unit consisted of 10 cm of pure aeolian materials overlying 20 cm of mixed aeolian deposits and agricultural debris. An occupation layer was discovered beginning at 35 cm below the surface. Cultural debris were excavated down to 70 cm below the surface.

Unit #4 South (U. #4 S.) lies 20 m northeast of U. #1 S. and is situated 5 meters from the edge of a domestic terrace, which was the reason for U. #4 S. being located here (See Chapter 7 for details).

Test Pit # 4 (T. P. #4 S.) was located 10 m from U. #4 S. in what appears to be an old "Huaquero" pit. This location was of interest because it contained a layer of somewhat-mixed Huayna Putina (H.P.) volcanic ash overlying a carbon lens varying 4-5 cm in thickness.

A carbon layer is often found directly beneath H. P. ash, and this stratigraphy has led at least one investigator, Jorge Tapia of the University of Pittsburgh, to hypothesize that the inordinate amounts of hot volcanic ash which fell over an extremely large area produced a regional conflagration. This hypothesis might be proven by future investigations, but it is noteworthy that none of the early 17th century chroniclers mentions any widespread fires in connection with the H. P. eruption, and there is not one allusion to even thatched roofs burning in Arequipa where the volcanic tephra fell continuously for three weeks.

Unit #5 South (U. #5 S) is located 20 m South of U. #1 S. in the low-lying area between the domestic terraces. This location was chosen because it appeared to be a likely place where debris would have been deposited. The 10 cm of grayish brown (10YR 5/2) aeolian deposits overlie 20 cm of Chuza flood deposits, which contained many rock fragments varying from .8 to 2 cm. The pinkish gray (7.5YR 6/2) Miraflores Flood deposits encountered at 30 cm contained rocks up to 30 cm, which is similar to the sediments found in U. #1 S. in the historic canal.

Unit #6 South (U. #6 S) is located 25 m farther South from U. #5 S. This location was selected because it appeared to be a prehistoric domestic terrace, which was confirmed by excavations. Excavations revealed that it had also been used as an agricultural surface by the Spanish or by the modern Peruvians. The (10YR 5/4) yellowish brown 7 cm aeolian layer was composed of fine sands,

some silts and clays. The 14 cm of (10YR 4/4) dark yellowish brown agricultural debris was composed of very fine silt with good clay content and very little sand. This agricultural stratum rested on 18 cm of (10YR 4/2) dark grayish brown sandy silt midden, which contained an admixture of pottery, including Chiribaya, Burro Flaco, and Colonial styles. The (7.5YR 6/6) reddish yellow Miraflores sediments composed of fine and coarse sands, with rock fragments and larger granitic rocks up to 18 cm, were found at 40 cm below the surface and did not contain any cultural materials. There were no Chuza deposits found in this unit.

Locations and Descriptions of the Geologic Columns

Geologic Column #1 (G. C. #1) is a 50 cm-wide column located ca. 500 m from the mouth of the main quebrada at the Pacific Ocean and 330 m Northwest of U. #1 S. This location was chosen because it is in a section of the quebrada where the strongest flood surges should have risen above the channel walls leaving overbank deposits. Further, since the column lies on the same line as the canal units, the absolute depths of the deposits at the two locations would allow for a comparison of the extent of the Miraflores Flood at both points (See Chapter 7).

Geologic Column #2 (G. C. #2) is located 120 m from G. C. #1 in a westerly direction toward the Pacific Ocean. This location was chosen because erosion had left a good geologic column with deposits from

the various El Niño events. The uppermost stratum was comprised of 5 cm of the 1982-83 El Niño deposits. While the Miraflores Flood commonly leaves much deeper deposits than does the Chuza Flood, the reverse was true at this location. The Chuza deposits were 50 cm thick, while the Miraflores deposits were a mere 5 cm. This rather large difference in the flood deposits leads to the conclusion that the Miraflores Flood was already waning, probably because it had lost so much of its sediment load several kilometers farther up the quebrada. Separating the two flood deposits was what appeared to be a 3 cm mixed layer of volcanic ash and carbon and 18 cm of aeolian deposits. It was later discovered that the Miraflores Flood had stopped 80 m farther downslope from this geologic column. Directly beneath the thin layer of the Miraflores deposits were Chiribaya cultural remains, which included 2 red, Chiribaya sherds and some seashells.

Geologic Column #3 is located 40 m downslope from G. C. #1. This spot was chosen because, once again, a second, deeper layer of what appears to be volcanic ash was included in the column, which incorporated rather unusual stratigraphy. Eight centimeters of 1982-83 deposits covered 28 cm of the Chuza sediments. Directly beneath these latter deposits is a 4 cm layer of volcanic ash with carbon immediately beneath it.

What is unusual about this column is the fact that there is a 90 cm stratum of aeolian deposits directly overlying another 1 cm layer of volcanic ash with some carbon under it. If chemical analysis of this layer proves it to be volcanic ash, then this thin stratum would

be evidence of possible seismic activity prior to the Miraflores Event. Heretofore, there has never been any volcanic ash found anywhere beneath Miraflores deposits. Underneath this last stratum of volcanic ash is 120 cm of the Basal Sequence. It seems reasonable that there should have been prior seismic activity before Miraflores to account for the excessive amount of flood debris associated with this singular event. However, it is also a possibility that this event was one of those extremely rare MegaNiños that occur once or twice a millennia (Sandweiss 1986).

At 120 meters West of G. P #3 is the narrowest part of the quebrada, measuring only 7 meters in width, and here the quebrada has been eroded down to the granitic bedrock. At this point, the Chuza flood deposits have diminished to only 16 cm, which is a good indication that the volume of this deluge had already begun to wane. Also of interest at this location was another small mixed layer of volcanic ash and carbon overlying 40 cm of aeolian sand, silt, and very small pebbles. Only at the Chuza Quebrada are aeolian strata found separating the deposits of the two major flood events.

Geologic Column #4 (G. C. #4) is located on the south side of the quebrada about 135 m upslope from the modern road. The south side of the quebrada was also investigated because the terrain on the north side of the quebrada is about 15 m higher, and, thus, more of the flood should have been forced to flow to the South and should have left deeper deposits there. Four cm of the 1982-83 El Niño silty sand overlie 52 cm of wind transported matter. Directly below the aeolian layer are the Chuza deposits, which are still well represented

here by a layer 46 cm thick. However, there are no Miraflores deposits. Chuza deposits at G. C. #4 are thicker because the bedrock stricture 30 m upvalley (East) forced the flood materials to rise. Fifteen meters upvalley from the stricture, Chuza deposits fluctuate from 18-25 cm thick. Beneath Chuza are what appear to be two different aeolian layers. The upper 30 cm appear quite normal, but the lower 30 cm are somewhat more consolidated than those generally found in other localities. Under the aeolian deposits are the deposits of the Basal Sequence.

There were substantial dry periods before and after the Chuza Flood because there is a layer of thick aeolian sands and silts lying contiguously below and above the Chuza stratum. The predominant northerly and easterly wind patterns along the coast always create an accumulation of sand or sand dunes on the south side of a quebrada channel. This same pattern is quite noticeable at the Chuza Quebrada where sizable aeolian layers are found interspersed between flood deposits.

Geologic Column #5 (G. C. #5) is located 60 m upvalley from G. C. #1. This location was chosen because this column is farther upvalley, and, therefore, the flood deposits from both the Chuza and Miraflores Floods were expected to be deeper. Beneath 2 cm of 1982-83 deposits were found 54 cm of Chuza sediments, which was substantially more than found at the other loci at Carrizal. No volcanic ash was noted, but there were 2 cm of carbon underneath the Chuza deposits. Rather than being deeper here, the Miraflores deposits were only 20 cm thick which was about 15 cm less than

these same deposits found in G. C. #1. A 20 cm layer of Chiribaya occupation debris, consisting of shells and 1 red Chiribaya sherd, was found immediately below the Miraflores deposits. The final deposits represented in the column were 220 cm of the Basal Sequence.

Location and Description of the Prehistoric Canal

Prehistoric Canal Profile #1 is 130 m above the fork in the main quebrada channel, about one kilometer from the olive grove (Figure 5-6). This location was chosen because I found a segment of an irrigation canal, which appeared to be the "intake" for the prehistoric irrigation system. A segment of the irrigation canal was totally washed away because the end of the canal is 7 meters from where the "intake" for the canal system would have been. In the bedrock bottom of the quebrada channel there is a natural, 8 m-wide "Choke Point" created by a very large boulder measuring 3.10 m in diameter. Some of the facing stones of the canal support wall had been disturbed, but the canal was originally of prehistoric Chiribaya construction.

At the north side of the 50 cm profile, 13 cm of grayish brown (10YR 5/2) aeolian sand and silt overlies 1 cm of Huayna Putina volcanic ash. Immediately below this volcanic ash, in the canal and overlying the canal facing stones, are the dark yellowish brown (10YR 4/6) Miraflores flood deposits of compacted silty sand, grit, and some small gravels. Above these flood deposits is a loose stratum of sand, small gravels, and rock fragments. These loose

materials are, apparently, the result of excavating what looks like a canal bottom directly into the Miraflores deposits; therefore, there is a slight possibility that the canal could have been reactivated by the Chiribaya, but this is very doubtful in light of the Miraflores flood's impact on the irrigated agricultural system. Even though 1600 A.D. H. P. ash lies 18 cm above the concave canal bottom, the more likely case is that the new canal was dug by the early Spanish settlers, since they had already occupied this region for decades before the Huayna Putina eruption. Covering the canal bottom were 9 cm of debris which included a few seashells, some unidentified bone fragments, and a piece of olive wood; however, no potsherds were included. Although there was a 2 cm layer of "puddled" 1982-83 sediments overlying this canal debris, unlike other locations, there is no 1982-83 El Niño sheet wash. Apparently the slope of 3-4 degrees is not enough to precipitate sheet wash at this location.

Agricultural Terraces

One hundred and twenty meters West/Northwest of the canal profile are some agricultural terraces which escaped the wrath of the Miraflores Flood; however, only 30 m beyond this point, all the terraces are covered by a huge 250 m by 600 m Miraflores rock and mudflow (Figure 5-7), which almost rivals in size the mudflow at Miraflores Quebrada (700 m by 900 m). Apparently 1 km above this point, the Miraflores Flood spilled very rapidly out of the narrower segment of the quebrada and covered the terraces. Unlike the other Carrizal locations investigated, there were no 1982-83 El Niño deposits present in the upper Carrizal Quebrada.

Figure 5-7: Miraflores Rock and Mudflow at Carrizal Quebrada

Investigations of this area included a 2.5 km jaunt up the quebrada searching for additional prehistoric fields and irrigation canals. Although no additional components of the prehistoric agricultural system were found, there were some Chuza and Miraflores deposits visible 4-5 meters higher up on the quebrada walls that were thus inaccessible to the investigator.

Shovel Testing at Carrizal Quebrada

Introduction

A number of shovel tests were conducted in the proximate area of the irrigation canal, on the agricultural terraces, to assess further the flood damage and to evaluate whether or not these surfaces may have been re-activated following the Miraflores Flood. Although it is often difficult to reach any substantial depth using a shovel, the uncovered strata frequently reveal useful information.

Location and Description of the Shovel Tests

Shovel Test #1 (S. T. #1) is located about 150 m downslope from the canal profile on some agricultural terraces which were unaffected by the Miraflores mudflow. Immediately below the aeolian deposits was a rich, 25 cm thick, organic layer presumably from Spanish Colonial agriculture since this stratum overlies Miraflores deposits. Since the Spanish introduced olive grove tending around 1555 A.D. (Kuon Cabello 1985), they presumably were able to re-activate these abandoned terraces when the climate became wetter at the beginning of the "Little Ice Age." Even though there is post-flood evidence that some Chiribaya people survived at

Carrizal Quebrada, it is highly unlikely that there would have been a sufficient labor force to re-activate the canal system following the Miraflores Flood.

Shovel Test #2 (S. T. #2) is located 50 m back upslope from S. T. #1 on another agricultural terrace. This probe exposed the same stratigraphy as the previous shovel test. Once again, immediately below the aeolian deposits was a deep rich, dark brown, organic layer, which had almost degraded into humus, capping the Miraflores deposits. This organic detritus must have come from Spanish Colonial agricultural activities because, to date, there is no archaeological evidence of any other culture practicing agriculture in this region until the arrival of the Spanish ca. 1540 A. D.

Shovel Test #3 (S. T. #3) is located 50 m Northwest of S. T. #2 and a meter from a small Spanish Colonial feeder canal. A little re-deposited Huayna Putina ash was discovered overlying the same thick agricultural layer. There are more small rocks in the agricultural layer here, and the soil is also more compact than in the other shovel tests. The presence of rocks leads to the conclusion that these lower terraces were also impacted by the Miraflores Flood but to a lesser extent than the others, and, thus, the Spanish were able to farm them.

Shovel Test #4 is located 50 meters West of S. T. #3. The findings of this probe were very similar to those of S. T. #3. Digging revealed a slightly rocky agricultural layer with somewhat

compacted soil. The Huayna Putina volcanic ash found in the previous shovel test was absent in this probe.

Shovel Test #5 is located 100 meters downslope from S. T. #4 in a defunct Lomas depression. A relic stand of tough, wild grass was found growing above the identical agricultural layer found farther upslope. The only difference here was the presence of salt/mineral deposits found beneath the grass intruding into the agricultural stratum.

Cultural Area North of the Carrizal Quebrada

There are some additional agricultural terraces situated about 200 m Northwest of the lower main quebrada channel which are almost void of any Miraflores flood deposits. There are, though, Miraflores deposits, resting below volcanic ash, in a prehistoric irrigation canal East and upslope from this midden. Apparently the small, rudimentary irrigation canal served as a run-off channel, which captured some Miraflores sheet wash. However, there are no Miraflores deposits on the higher domestic terraces West of the agricultural surfaces.

Oddly enough, there are Chuza-like deposits overlying a Chiribaya midden. These sediments could be from Chuza sheet wash because there is no other evidence that either the main flood surge of Chuza or Miraflores ever reached this much higher location. Shovel testing on the highest point exposed some Post-Chiribaya Burro Flaco style pottery.

Excavations at Miraflores Quebrada

Introduction

The aerial view of the Miraflores Quebrada (Figure 5-8) gives dramatic proof of the enormous size of the 14th century flood recently discovered at this location. This 700 m by 900 m mudflow totally covered the approximately 140 m by 140 m Chiribaya settlement (Figure 5-8A). The approximate limits of the lighter-colored historic Chuza flood deposits are shown at 8B. Besides the many flood covered domestic terraces, the most striking features at this quebrada are the two large, rectangular sunken features. Despite the fact that they have been inundated by two major flood events and centuries of aeolian dust and silt, these 2+ m deep features are still noticeable (Figure 5-8C & -8D) even at the 1:8500 scale of this figure. Figure 5-9 shows the locations of the units at the Miraflores Quebrada.

Sunken Features at Miraflores Quebrada

Ceremonial architecture has a long tradition in the Moquegua Drainage. Dating to ca. 5000 B.P, structures found at Asana are perhaps some of the earliest ceremonial architecture in southern Peru (Aldenderfer 1991). There are two sunken rectangular features, covered by flood deposits, at Miraflores Quebrada which may reflect this long-standing tradition. Pit #1 measures 6 by 8 meters, while Pit #2 is 8 by 10 meters. Both of these features have smooth clay floors about 12 cm thick.

Pit #2 also has a row of worked stones dividing the feature into two equal parts (Figure 5-10). This distinguishing characteristic

Figure 5-8: Aerial View of Miraflores Quebrada

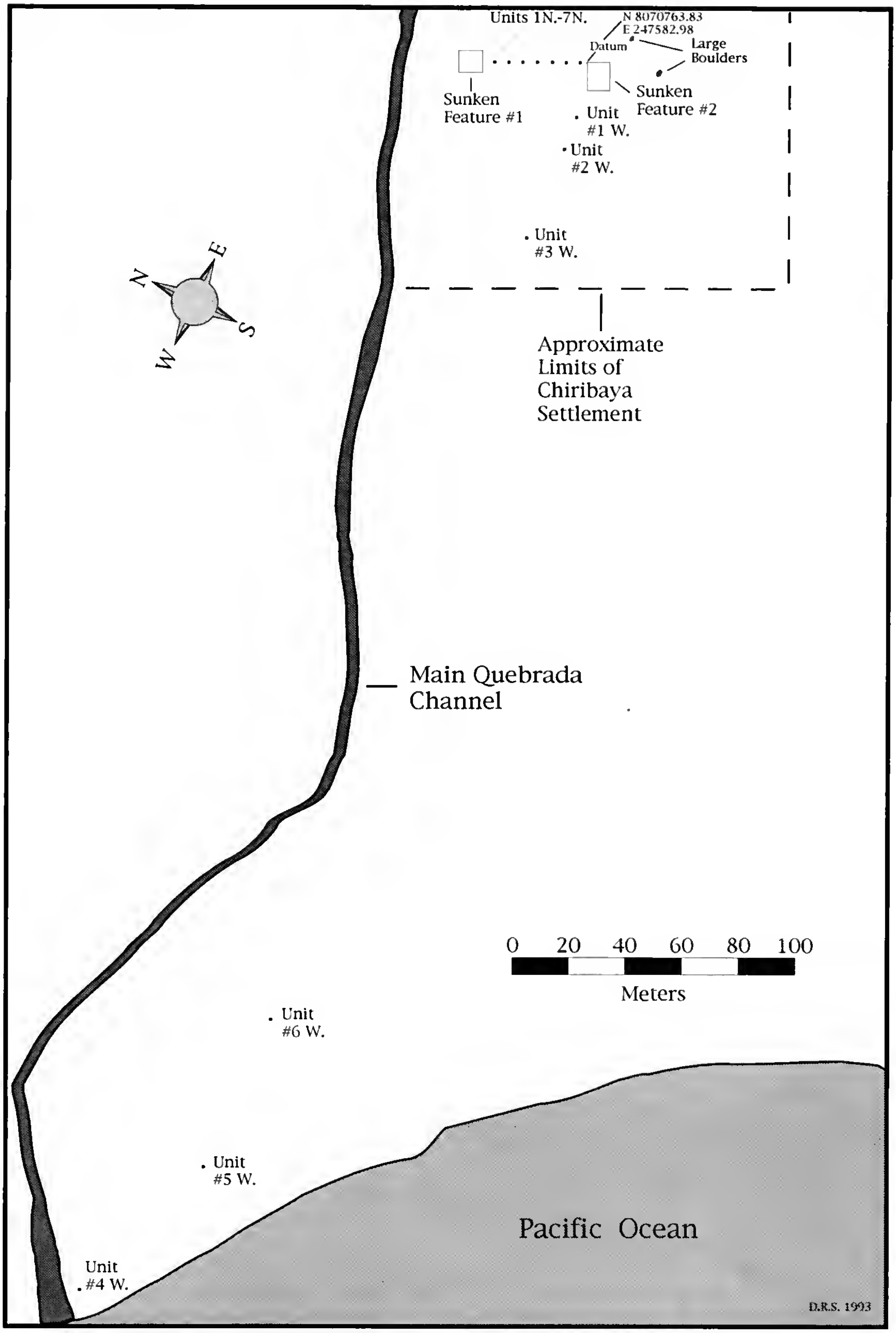


Figure 5-9: Miraflores Site Plan

Figure 5-10: Sunken Feature #2

could be interpreted as a division for two moieties or kingroups, reflecting the dual organization of the Chiribaya society, which perhaps used the individual halves of the sunken features for religious ceremonies. Such dual societal organization has been proposed for some regions of Peru even as early as the PreCeramic Period (Grieder et al. 1988; Burger 1988). Further, sunken courts, both the earlier circular type and the later rectangular versions, are architectural features found almost ubiquitously on the Peruvian coast and in the highlands at various sites, spanning thousands of years of cultural history (Moseley 1985; Pozorski and Pozorski 1987; Chávez 1988). There are at least two, and possibly three, sunken features at the Pocoma Quebrada. However, I was unable to excavate these features and, therefore, I am unsure if the features at Pocoma also had clay floors and/or a dividing row of stones.

During the course of my investigations, certain questions arose concerning the origin and use of these features. For example, these sunken pits may have been constructed for the exclusive use of the inhabitants of their respective quebradas, even though the Chiribaya were an ethnically homogeneous population. Or perhaps the people from other coastal quebradas, lacking such facilities, congregated at Miraflores or Pocoma for important religious rituals or other significant secular ceremonies, depending on whether they belonged to the *hanan* (upper) or *hurin* (lower) moiety. It could be that the sunken pits at Pocoma were built after those at Miraflores were rendered useless by flooding. However, lacking sufficient data from Pocoma, one can only speculate on what the exact relationship was between the two quebradas.

Location and Description of Units and Geological Columns

Excavations at Miraflores Quebrada began with a series of seven units, placed on 5 meter "centers" between the two large sunken features (Figures 5-10 & -11). These units will be discussed as an integrated whole because of their close proximity and their South-to-North orientation. The depths of the Chuza and Miraflores flood deposits vary very little in each unit because they all lie on the same plane, and, thus, the floods would have reached the units simultaneously. This phenomenon should account for the fact that the excavations of these units yielded similar data.

These seven units were oriented along a transect of 330°. The center of U. #1 N. was located 5 meters from a datum stake set at the Northeast corner of the southern sunken feature (Pit (P.) #2). In general terms, Units #1-#7 North (U. #1-#7 N.) all contained 3 identical strata (U. #1 N. and #3 N. are further discussed in Chapter 7). The uppermost 4-8 centimeters were composed of an dark yellowish brown (10YR 4/6) aeolian layer of dust and silt. Directly beneath this stratum were the 18-20 cm deep deposits of the Chuza Flood composed of (7.5YR 4/6) strong brown deposits of silt, sands, and a multitude of small rock fragments which directly superimpose the dark brown (7.5YR 4/4) Miraflores flood debris. Only the Chuza deposits had any included materials, and these were usually of historic vintage.

Quite often the Huayna Putina volcanic ash, which serves as a constraining chronological marker for excavations in the Moquegua Drainage, is found separating these two flood layers, but it was

Figure 5-11: Sunken Feature #1

conspicuously absent in these units. Perhaps, the Chuza flood surge, like the Miraflores, was unimpeded in its downhill flow toward the Pacific Ocean and obliterated the thin layer of volcanic tephra. Since, at the contact point with the Chuza deposits, the Miraflores deposits are so often highly compacted, it would be interesting to determine if the moisture content and the chemical composition somehow react with the volcanic ash to help produce this very hard layer.

Large Unit #1 (L. U. #1) is a large 2 m by 2 m probe excavated into the east wall of the northernmost sunken pit (Pit (P.) #1). Because the 7 units yielded so few artifacts, the east side of the pit was chosen for excavation because it lies 8.5 m closer to the quebrada mouth and would have been struck first by the mudflows. Furthermore, there was a possibility that since the "pit" is 2 meters deep, some cultural material may have been trapped and preserved.

Unit #1 West (U. #1 W.) is located 10 m due West (270°) from the datum stake at the southern sunken Pit #2. The Chuza Flood begins at 2 cm below the aeolian layer and extends down to 30 cm where it meets the Miraflores Flood. The Chuza flood deposits in this unit are not as consolidated as in the seven units between the two pits, although the aerial photo shows the Chuza Flood extending about 300 m farther downslope (Figure 5-8B). It may be that the Chuza flood lost some of its excess moisture by the time it reached this point.

Unit #2 West (U. #2 W.) is located 10 m farther to the west of U. #1 W. in an effort to better analyze the depth of the flood sediments. The Chuza deposits here do not begin until 15 cm below the surface. The aeolian deposits may be deeper in this unit because the wind should tend to bank the dust and silt against the front faces of the domestic terrace support walls.

Unit #3 West (U. #3 W.) is situated 30 m farther West of U. #2 W. The deeper I dug in this unit, the more compact the Chuza deposits became, to the point that they were almost as hard as the deposits left by Miraflores. Since very little of a diagnostic nature was found in the Chuza deposits, when the Miraflores sediments were encountered, I stopped excavating.

Unit #4 West (U. #4 W.): Because excessive time was being spent in excavating the very hard flood deposits, the decision was made to locate this unit as close as possible to the edge of the marine terrace in an effort to ascertain whether or not the Miraflores Flood truly reached the Pacific Ocean. Thus, this unit is located 5 m from the south side of the quebrada and 10 m East from the edge of the marine terrace where it slopes sharply down to the beach (See Chapter 7).

Unit #5 West (U. #5 W.) is located 40 m East and 25 m South of U. #4 W., and its location was chosen because of the depression 1.5 m below the level of U. #4 W. It was presumed that more cultural debris could have collected in this small swag (See Chapter 7).

Unit #6 West (U. #6 W.) lies 50 m due East of U. #5 W. Excavations were stopped when I encountered Miraflores because the deposits were inviolable, solidified caliche. However, twenty plus cm of Chuza deposits were dug and screened. There were no sherds found in this unit. The only remains recovered from the Chuza deposits were carbonized shells.

Trench #1 West (Tr. #1 W) is a 1 by 2 meters excavation located 25 m due West of U. #5 W. This trench was cut into the edge of the marine terrace to determine if the Miraflores Flood really continued its surge to the sea (See Chapter 7).

Survey of the Upper Miraflores Quebrada

Pedestrian survey of other areas of the quebrada revealed that the there is a fairly good spring flow at Miraflores, but, nevertheless, the water is insufficient and must be stored for later use. Most of the water for the olive grove is now pumped from subterranean sources. There are abandoned colonial/modern fields on the south side of the quebrada lying immediately East of the modern road. Located on the south side of the olive grove is a small, stone-lined colonial irrigation canal adjacent to a reservoir for irrigation water. A portion of this canal is now cement-lined to better prevent erosion from the rush of irrigation water as it is released from the holding tank.

Geologic Column #1 (G. C. #1) is located in a small fork East of the main quebrada channel about 100 m from the upper edge of the modern olive grove. This location was chosen because the deposits from all of the presently known El Niño events in the Ilo region, are clearly visible here in an unbroken 2.10 m column.

There were no prehistoric agricultural terraces or irrigation canals located in this small tributary, but there is an artificial dam positioned 54 m upvalley from G. C. #1. The dam is 20 m wide and 2 m high. Located adjacent to this impoundment is a small colonial canal. The dam appears as if it had been damaged by an El Niño flash flood since over 10 m of its center has been washed away. Five hundred meters farther upvalley from the dam, the quebrada narrows to a 15 m wide, very steep-sided gully (30°).

All of the Miraflores flood flow would have been contained in this small ravine until it reached the main quebrada where it would have joined and augmented the mudflow from farther upvalley. These materials should have been contained within the quebrada until they reached the quebrada mouth where they would have disgorged and fanned out rapidly over the Chiribaya settlement. The speed of the flood would have been substantial (around 112 k.p.h.; see Chapter 8) since the slope of the quebrada channel is 10 degrees.

Geologic Column #2 is located in the wall of the main quebrada channel one kilometer upvalley from the olive grove. This spot was chosen because the quebrada is fairly steep here, with a slope of 25°, and the flood events are clearly visible in the banks of the channel (See Chapter 7).

Excavations at Pocoma Quebrada

Introduction

Figure 5-12 is an aerial photograph showing the general terrain surrounding the Pocoma Quebrada. Figure 5-13 indicates the important features of the quebrada including: The domestic and agricultural terraces denoted by 13A and 13B; The High and Low canals on the slopes of the quebrada at 13C and 13D; the olive grove at 13E; and the units, the terrace wall profile, and Geologic Column #1.

Location and Descriptions of Units and Profiles

Profile #1 of Terrace Wall (T. W. #1) lies 10 meters from a 6.5 m wide stone-lined tomb, which has been looted. This interesting location was brought to my attention by UNM graduate student, Rick Reycraft, who was also doing research at Pocoma Quebrada. This terrace wall is extraordinary because it was built directly on top of the Miraflores flood deposits, and it is the first evidence of rebuilding by the Chiribaya people after the Miraflores Event (See Chapter 7).

Unit #1 (U. #1) is located on a combined agricultural/domestic terrace 5 m from T. W. #1 on a heading of 60°. Since the Miraflores deposits were present at the terrace wall, this location was chosen to further analyze the impact and to determine if there was any additional evidence of rebuilding. The Chuza deposits are absent from this unit, and the Miraflores flood detritus rapidly becomes

Figure 5-12: Aerial View of Pocoma Quebrada

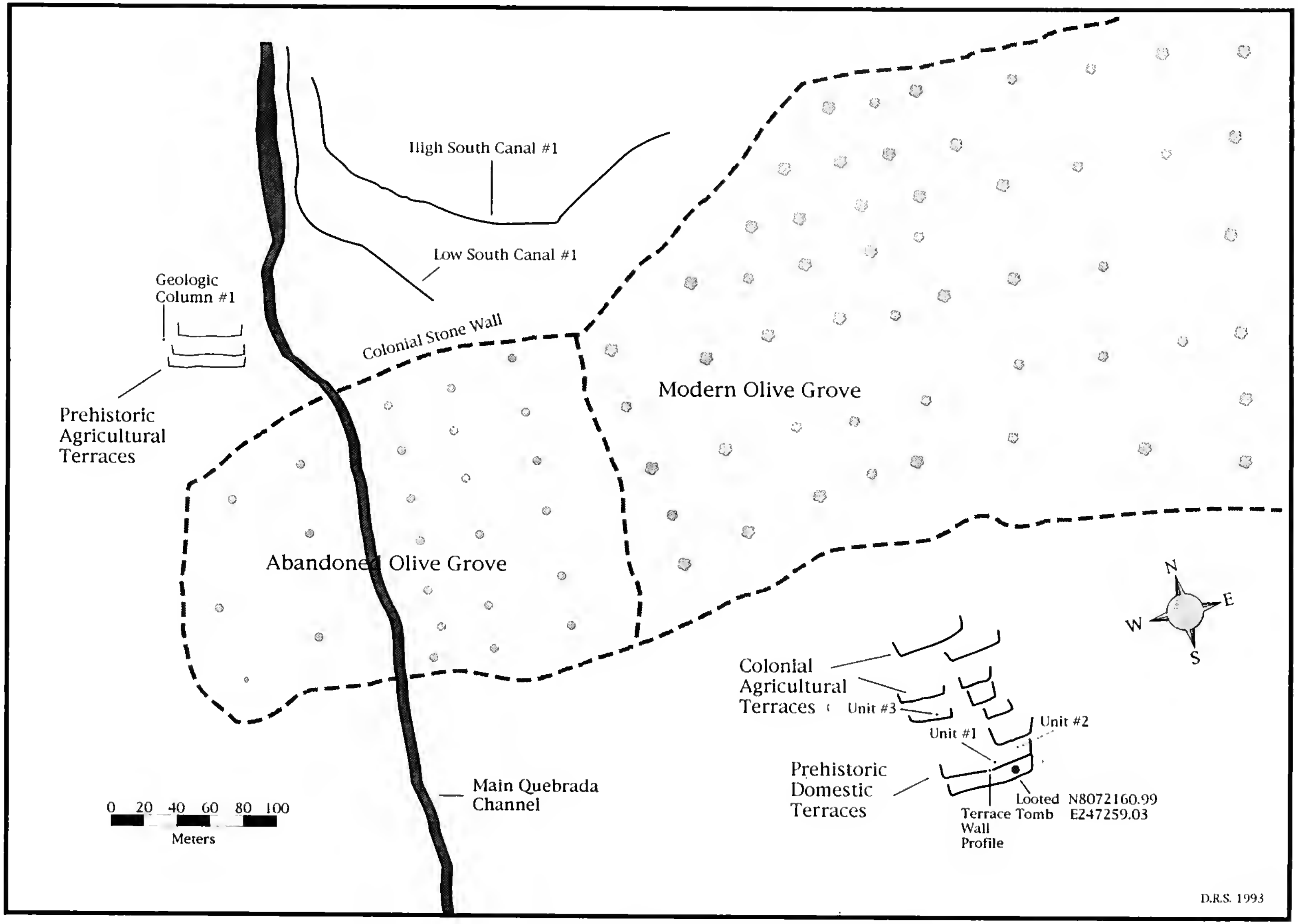


Figure 5-13: Pocoma Quebrada Site Plan

caliche within 30 cm of the surface. Other than a pocket of arcilla (whitish clay), nothing significant was found in U. #1.

Unit #2 (U. #2) is located 19.5 m from the center of the badly disturbed stone-lined burial chamber. The large tomb (6.5 m E-W and 5.5 m N-S) has been so damaged that it is virtually impossible to say for certain whether or not this structure was a *Proto-Chullpa,* an above ground stone burial chamber. Unit #2 was perhaps the most artifactual laden unit of the entire field season (See Chapter 6 below for a detailed account of the recovered data from all quebrada units). This unit was quite exciting because it contained the cane wall from a new dwelling which was built directly on top of the Miraflores deposits (See Chapters 6 and 7).

Unit #3 (U. #3) is located 45 m Northwest of U. #1 because an agricultural terrace exists here. Agricultural refuse mixed with cultural remains found in the upper levels of this unit leads to the conclusion that this area was once a domestic terrace which was later used for agricultural purposes. A layer of midden is found directly overlying the Miraflores reddish yellow (7.5 YR 6/6) deposits, whose composition looks identical to that of the sediments found in U. #1. This positioning of the strata supports the conclusion concerning the evidence from U. #2 that at least some of the Chiribaya survived the Miraflores Flood and were able to continue their daily lives. No indication of the Chuza Flood could be found on this agricultural/domestic terrace.

Location and Description of Shovel Tests

Shovel Test #1 is located 85 m North and 25 m East of U. #2 on what is believed to be an historical agricultural surface. Probing here exposed 10 cm of agricultural refuse overlying 40 cm of Chiribaya midden, which included sea shell fragments and very small pieces of pottery. Miraflores deposits were once again encountered, but were found at a shallower depth of 50 cm below the surface. There are no Chuza deposits here, but it is interesting that there is some Chuza sheet wash even in the High Canal on the north side of the Pocoma Quebrada (see below).

It should be noted that some of the later possible Post-Flood cultural materials found at Pocoma and in the surrounding areas are now referred to as originating from the Burro Flaco Complex, a series of maritime settlements located near some of the coastal quebradas (Penmann and Bawden 1991). This classification is based in part on the excavations and the interpretations of the type site of Burro Flaco by Ms. Shawn Penmann of the University of New Mexico. Burro Flaco is located about 400 m West and downslope from the units which I have been discussing. Most of the Burro Flaco pottery is very drab, but a few polychromatic sherds have been found. Although the decorated pottery from Burro Flaco is different from the Chiribaya but similar to the Chilean San Miguel pottery, the current sample is too small to make any definite statement about motifs or iconography (Shawn Pennman Personal Communication 1993).

The idea that the Burro Flaco Complex was a separate fishing-based social unit, contemporaneous with the Chiribaya, was based on an early model developed by Garth Bawden, Director of the Maxwell

Museum at Albuquerque, New Mexico. However, since the discovery of the Miraflores Flood, this model has had to undergo some modification. It is now unclear whether: 1) the Burro Flaco Complex was a separate maritime-based society before the flood; or 2) whether it developed after the Miraflores Event; or 3) it remained a separate contemporaneous ethnic entity both before and after the Miraflores Flood and some post-flood members of the Chiribaya Culture were later assimilated into the Burro Flaco society. Lacking sufficient ^{14}C dating, it is currently impossible to assign an accurate chronology to the Burro Flaco Complex. Additional research is needed at the Burro Flaco Site and at the Carrizal and Alastaya Sites before we can accurately determine the nature of the Burro Flaco Complex with regards to the much larger coastal Chiribaya population (Garth Bawden personal communications 1993) since it has also now been proposed that some of the Chiribaya living in the Ilo Valley had been part-time fishing specialists (Owen 1992b).

Shovel Test #2 (S. T. #2) is located on a different terrace 15 m East of S. T. #1. Excavations exposed a 4 cm deep layer of wind deposited sand and silt. A 2 cm layer of redeposited Huayna Putina ash was found overlying 30 cm of agricultural refuse. Although the rains associated with the Chuza Event were sufficient to create sheet wash on the steeper slopes, the gentler slopes of the terraces only allowed the rains to disturb the volcanic ash, but, at the same time, were not sufficient to move noticeable Chuza sediments. There was no evidence of human occupation, such as sea shells or sherds, found

in the agricultural stratum, which leads to the conclusion that this particular terrace may never have been occupied.

Prehistoric Terraces

Ground survey of the quebrada involved the investigation of the abandoned agricultural terraces North of the olive grove. The terraces, which lie the farthest upslope, are completely covered by only Miraflores deposits. The lower-lying terraces bordering the quebrada channel include Chuza deposits overlying the Miraflores alluvium, which also overflowed the banks of the quebrada at this particular location.

1982-83 Run-off Channel

Fifteen meters from the main channel of the quebrada is a cut made by the run-off from the 1982-83 El Niño rains. There is a .5 cm veneer of 1982-83 mud, composed of fine sands and silt, plastered over the top of the Miraflores sediments that lie at the bottom of this cut. Chuza deposits consist of a 27 cm thick layer of dark yellowish brown (10YR 4/6) silty, gritty sand with very small rock fragments (less than .5 cm) and small pebbles (less than 1 cm). This Chuza debris directly overlies the 60 cm thick stratum of Miraflores deposits, which had to be divided into two components. The first 28 cm of the Miraflores stratum is yellowish brown (10YR 5/6) very compacted sandy silt with rocks up to 20 cm in size.

The last 32 cm of Miraflores is dark yellowish brown (10YR 3/6) very compacted sandy silt with some clay particles, small rocks, and includes many root hairs. The reason that the lower deposits are

darker is probably because of the organic materials from the agricultural terraces which the leading edge of the flood pushed in front of its wake. Despite the salient profile left by the erosion of the 1982-83 rains, there were no cultural remains visible in either of the flood strata.

Irrigation Canals

The #1 High North Canal (#1 H. N. C.) is located on the north side of the Pocoma Quebrada. Much of the canal has been totally eroded away by previous El Niño sheet wash and floods, except for a 20 m canal remnant at the extreme upper valley end, and, thus, was an ideal location for a trench profile. There is exposed bedrock about 35 m from the intake end of this canal near what appears to be a now defunct spring source for the Chiribaya irrigation system. There are still a few dead olive tree stumps located at the edge of this canal which could be interpreted as an indication that the Spanish had somehow reactivated the canal. However, a test trench in the canal revealed that it saw perhaps some use after the Miraflores Flood, because the canal bottom, which lies directly above the Miraflores deposits, has little evidence of water transported sediments. However, the construction indicates that the canal was originally part of the Chiribaya irrigation system.

The #2 High North Canal (#2 H. N. C.), which is 1.30 m at its widest point, is located about 15 m above the quebrada bottom on the north side of the Pocoma Quebrada, and it is obviously a continuation of the #1 H. N. C. Both the #1 and #2 High Canals have outside stone-faced retaining walls, which helped support the canals on these precarious slopes. This #2 canal extends for about 75 m up

(NNE) the main branch of the quebrada toward the exposed bedrock at the spring source. There is a colonial rock-wall enclosure which possibly served as a domestic livestock corral. Since this enclosure is built over the #2 High North Canal in two places, it seems probable that this enclosure is from the later Spanish Colonial Period (See Chapter 7).

The #1 Low South Canal (#1 L. S. C.) is located on the south side of the quebrada 4.5 m above the bottom of the quebrada. The location for the profile was chosen on the basis of the remnants of olive tree trunks visible along this canal, and the fact that 10 m beyond this point all traces of the canal have been obliterated. Unless there were prehistoric agricultural terraces that have since been covered over by colonial or modern agricultural endeavors, today there are no visible prehistoric agricultural terraces which the #1 L. C. S. could have irrigated.

The #1 High South Canal (#1 H. S. C.) is located on the south side of Pocoma Quebrada about 25 m above the quebrada bottom. The profile location was selected because the support wall and the irrigation canal were intact, while other sections of the canal were so damaged that a profile would probably not contain diagnostic data (See Chapter 7).

Geologic Columns

Geologic Column #1 (G. C. #1) at Pocoma was located in a "cut" made by heavy excavation equipment. The rectangular hole, which exposed an excellent two meter tall column, was probably a "borrow pit" for fill materials used in local road construction. The cut is

located 75 m North of the quebrada channel and 80 m Northeast of the colonial stone wall which once enclosed a now abandoned olive grove (See Chapter 7).

Location and Description of Shovel Tests

Shovel Test #1 (S. T. #1) is located on an agricultural terrace Northeast of the colonial wall and the quebrada channel. This probe exposed a 7 cm layer of aeolian deposits resting on 43 cm of Chuza sheet wash. However, this terrace had been farmed sometime after the Chuza Event. The deposits were composed of sandy silt with a good clay content which is to be expected because of agricultural activities. Cultural debris found included one Colonial sherd and a few seashells. Also present were some very fine root hairs from some unknown domestic plants. Wild plants rarely grow anywhere along this region of the coast, with the exception of El Niño years when some long dormant seeds will sprout. Even most of the Lomas here have been devoid of any vegetation for decades.

Shovel Test #2 (S. T. #2) is located on the second agricultural terrace upslope (East) of S. T. #1. Wind deposited fine sand and silt measured 5 cm in depth. The Chuza deposits are more compacted here, although they are almost identical in depth (i.e. 49 cm) to those found by S. T. #1. The deposits here are perhaps more dense because of the inclusion of rocks 5-10 cm in diameter on this terrace. Nevertheless, the sediments were still composed of sandy silt with good clay content. I found a few more seashells and some root hairs,

but no cultural materials in the upper half of the Chuza sediments, though there many more seashells in the lower deposits.

Shovel Test #3 (S. T. #3) is located North of the colonial wall on the second terrace downslope (West) of S. T. #1. Aeolian deposits measured 4 cm deep here. The Chuza deposits (36 cm) are more compact on this terrace than at S. T. #2, but they are still comprised of sandy silt with clay. I only found a few shells and a scant few root hairs in this test. A major limitation of shovel testing is the inability to excavate deeply, and, therefore, I was unable, in most places, to excavate deeply enough to reach the debris from the Miraflores Flood.

Shovel Test #4 (S. T. #4) is located two terraces downslope from S. T. #3 on the lowest visible agricultural terrace approximately 50 m Northwest of the colonial stone wall. Here probing revealed 4 cm of aeolian deposits overlying 30 cm of Chuza sediments consisting of sandy silt with clay particles. This probe was the shallowest because the very compacted flood deposits only allowed excavating to a total depth of 34 cm. However, since cultural materials had been so scarce on these terraces, I was very fortunate in finding one Burro Flaco sherd here.

Shovel Test #5 (S. T. #5) is located two terraces upslope from S. T. #2. The remainder of the agricultural terraces extending upslope for 45 m from S. T. #5 are totally covered by flood debris and rocks which fluctuate from 10 cm to one meter plus in size. The aeolian level was only 3 cm thick here. The Chuza deposits were 41 cm deep, but I was finally able to find evidence of the Miraflores Flood on the agricultural terraces, and so I dug down 20 cm searching for

cultural remains. The Miraflores deposits were somewhat finer than usual, and they only included rocks up to 15 cm. However, I believe that the increased number of rocks helped to trap the finer sediments. I again found only one Burro Flaco sherd and even fewer seashells, but no Chiribaya materials.

Shovel Test #6 (S. T. #6) is located on an abandoned olive agricultural terrace 25 m NNE of S. T. #5 and 30 m East of the G. C. #1. At this location, there are a series of colonial terraces with small depressions for watering olive trees. The wind borne sands are 5 cm thick and overlie only 16 cm of Chuza deposits. The shallower Chuza deposits here indicate that the volume of the Chuza mudflow was waning at this point because these terraces are situated at about the same elevation. Therefore, as the Chuza mudflow surged downslope, spreading laterally at the same time, its total force and volume were dissipating by the time they reached the olive terraces.

The strata in S. T. #6 was the most unusual found during the shovel testing. Beneath a 16 cm layer of Chuza deposits was a 4 cm layer of sand directly followed by 12 cm more of flood deposits. Immediately beneath this second flood layer was a 21 cm thick midden overlying at least 5 cm of Miraflores deposits.

The 4 cm sand layer is definitely not of aeolian origin. Perhaps, it was deposited by the slackwater phase of the Chuza Flood. If this sequence is true, then there must have been a second flood surge involved with the Chuza Event. Evidence contained in a geologic column at the Planting Surface #1 also indicates that there were possibly two phases of the Chuza Flood.

I found many shells in the lower portion of the Chuza deposits immediately overlying the midden. Based on the stratigraphy, I believe this midden is the same one which I encountered in the G. C. #1, 30 meters west of S. T. #6. There were, as commonly is the case, no cultural materials in the Miraflores sediments.

Investigations in the Ilo Valley

Introduction

Lacking official permission from the INC (Instituto Nacional de Cultura) to conduct excavations in the Ilo Valley, investigations were necessarily limited to observing and measuring the accessible flood stratigraphy in the river bank, cleaning and drawing a few geologic columns, a few shallow probes on some of the agricultural terraces, and one trench in an historical irrigation canal.

The Ilo Valley Flood Sequence

Since the flood sequence for the Ilo Valley has been discussed in detail in Chapter 3, a brief overview will suffice here. In general, the Basal Sequence (B.S,) has the oldest and deepest deposits with a strata as thick as 8.5 m. Lying directly above the B.S. are the 14^{th} century Miraflores sediments which fluctuate from 2-6 m in thickness. The 1600 A.D. Huayna Putina ash is generally found in a thin 1-3 cm stratum. The 1607 A.D. Chuza Flood deposited a layer that is 1-2 m thick. The fine sediments of the 1982-83 El Niño are visible on the valley floodplain and in the bottoms of the large

quebradas that run perpendicular to the Ilo Valley. Traces of the 1991-92 El Niño have now been added to the flood sequence.

With the exception of the 1991-92 and the 1982-83 El Niño deposits, the flood stratigraphy in the valley is almost identical to that found in the three coastal quebradas. The marked difference between the two stratigraphies, separated by some 30 km, is the depth of the flood deposits in the Ilo Valley, which are substantially thicker than those found at the Carrizal, Miraflores, or Pocoma Quebradas. The reason for the disparity is the fact that there are a series of lateral quebradas that channel viscous materials into the river channel.

Agricultural Terraces

The quebradas not only add to the total volume of flood materials, but they also substantially add to the destruction of the irrigation system components. Even a cursory field survey of the Ilo Valley would quickly reveal that none of the agricultural terraces escaped the Miraflores Flood. The highest terraces are totally covered with flood debris that is an estimated 10 meters or more deep at some locations. Even the lowest terraces all have at least sheet wash, varying in depth from 30-78 cm, which again is deeper than that found on the terraces along the coast.

Planting Surface #3 was the only location where limited shovel testing uncovered any plant remains, and these were sparse. One corn cob of the variety grown by the Chiribaya and some corn husk fragments were discovered here. Limited shallow tests of the agricultural terraces at P. S. #1 and #2 revealed no agricultural

refuse. Since the presence of the corn cob might be considered an aberration, it is possible that the cob was carried from elsewhere and deposited by the sheet wash.

What Do Excavations Indicate about the Flood Severity?

Introduction

The lack of Pre-16th century written records concerning heavy rains and flooding in Peru, compels a researcher to rely on data recovered through site survey and excavations. Careful analysis and synthesis of these data can help create an oftentimes quite accurate account of past events. The focus of this dissertation research was primarily to assess the impact of a mammoth flood event on the irrigated agricultural systems located in the coastal quebradas and in the Ilo Valley. Data concerning the Chuza Flood were used for comparative purposes since it was also a very large flood event, which left considerable deposits in the study area. Evidence from each quebrada and the valley presents a slightly different scenario. The following is a description of the severity of the flood episodes, with particular emphasis on the Miraflores Flood, based on field observations, excavated data, and stratigraphy.

Impact at Carrizal Quebrada

Although the 1982-83 El Niño was the strongest perturbation in the last century, its impact on the modern people and their agriculture in the Ilo area was inconsequential compared to the

impact of the Miraflores Event on the prehistoric agriculture. It is a fact that the mudflows associated with the 1982-83 El Niño rains covered the spring at the La Yara quebrada causing the eventual abandonment of this small olive grove (Moseley et al. 1993). However, the Miraflores Flood not only buried springs, but it virtually annihilated the largest irrigated agricultural system ever to operate in the lower Moquegua Drainage.

Analysis of the Miraflores deposits at Carrizal indicate that the Miraflores Event was a widespread event that was perhaps worse than any other known El Niño perturbation, though some of the flood events represented in the Basal Sequence may have been as large or even larger than the Miraflores Event. Based on the data from the units excavated at Carrizal the following interpretation seems probable. Since only the units that do not reside on the domestic terraces show flood deposits from both the Chuza and the Miraflores floods, it is reasonable to conclude that the residents of these terraces were unaffected directly by the Miraflores Flood. The large irrigation canal at the base of the domestic terrace was used briefly for irrigation purposes, but probably not by the Chiribaya because the agricultural terraces below the domestic terraces were covered by the Miraflores Flood. The test trench in the canal shows that an irrigation canal bottom exists above Chiribaya cultural debris, but if there were no viable agricultural terraces to irrigate, then it seems that the canal sediments were probably from later use by non-Chiribaya people who re-activated some of the abandoned agricultural surfaces.

The geologic columns demonstrate that both of the floods continued their flow for at least 200 m beyond the location of the domestic terraces on the south side of the quebrada. The depth of the Chuza deposits present in the geologic columns seem to indicate that the Chuza Flood was a larger event than the Miraflores Event. Of course, investigations of the entire region prove the opposite to be true. The reason for this disparity is the fact that the Miraflores Flood dropped most of its sediment load on the agricultural terraces in the upper quebrada according to field observations in this area.

Ground survey, stratigraphy of the canal profile, and the data from the shovel testing in the upper quebrada all lead to the conclusion that the Miraflores Event totally destroyed the irrigated agricultural system with a single mudflow of mammoth proportions. Although some of the terraces nearer to the quebrada channel were unaffected by this mudflow, at least 75% of the available agricultural surfaces were covered by the Miraflores Flood. Probing of these terraces show a rich organic layer composed of root hairs and unidentified vegetal fibers overlying Miraflores deposits, but, at the moment, there is no evidence to support the position that the Chiribaya had re-activated the terraces following the flood.

Assessing the impact on the domestic terraces, about 200 m North of the main quebrada, was the most challenging. The only evidence of the Miraflores Flood found was sheet wash in what resembles a small rudimentary irrigation canal. However, since the Miraflores Event was so much stronger than the Chuza Flood, it is difficult to explain adequately the presence of what look like Chuza deposits overlying cultural midden at a location that is even higher

in elevation than the "irrigation canal". Since not much time was spent investigating this area of Carrizal, additional research is needed to solve this enigma.

The 1982-83 flood deposits at Carrizal are characterized by a silty sand cap that varies from 10-14 cm in depth. The adobe-like deposits are found plastered against the wall of the quebrada, 2-3 m above the floor of the channel. These sediments differ in both depth and composition from those investigated on the north coast of Peru. There the sediments are "characterized by a 50- to 100-cm-thick basal gravel, overlain by a 10- to 100-cm-thick sand bed, grading into a 1- to 10-cm-thick silty sand bed and capped by a very thin layer of silt or clay" (Wells 1987:14,463). The reason for this dissimilarity is the fact that the northern Peruvian valleys normally receive more rain during an El Niño perturbation, and it is only during very strong events that the El Niño rains ever reach far-southern Peru (Waylen and Caviedes 1986).

Impact at Miraflores Quebrada

Miraflores Quebrada presents the most dramatic setting for the greatest potential human devastation anywhere in the study area. More units were excavated here than at any other location, and, yet, less artifactual data were recovered at Miraflores than in the other locations. As soon as excavations began, I was immediately awe-struck by the absence of even pottery sherds, especially since sherds are so commonly found on the surface at other locations. With the exception of cultural material recovered from the 2 by 2 m probe in

the east wall of Pit #1, the entire floodplain is almost totally devoid of cultural remains for a distance of 400 plus meters. We cannot categorically state that the quebrada was occupied when the Miraflores Flood struck, but if it were, then the entire Chiribaya population living at the quebrada would have been instantaneously pushed into the Pacific Ocean by the estimated 5-6 m high leading edge of the flood, surging down upon them at more than 110 k.p.h.

The immense power of this swift moving flood is verified by the fact that boulders larger than 3 m rest slightly South of Pit #2. S. Terrace facing stones and rocks, longer than one meter, rest at the very edge of this marine terrace over 400 m from the sunken pits and rich organic debris found in some of the units could have come from the agricultural terraces that lay more than a kilometer upslope.

There is absolutely no trace of a prehistoric irrigation canal--every component of the irrigation system had been totally obliterated by an event that seems to have been worse than the wrath of God. The steep slopes (25-30°) of the Miraflores Quebrada would have restrained the total mudflow until it reached the quebrada mouth where it would have instantly fanned out across the total area destroying everything in its path. There is not one shred of evidence of anyone or anything surviving this 14^{th} century gargantuan flood at Miraflores Quebrada.

<u>Impact at Pocoma Quebrada</u>

There is evidence of heavy damage to the irrigation system at Pocoma. Most of the High Canal on the north side of the quebrada

has been totally washed or eroded away. One 20 m-long intake section of canal exists near the presumed spring source for this canal. Another 75 m section of canal is found farther down valley from this intake section, but the rest of the contour canal which ran up the main branch of the quebrada is now utterly non-existent.

All terraces show evidence of flood damage, although the combined Chuza and aeolian deposits were too deep to allow reaching the level of the Miraflores deposits. The last 45 m of terraces nearest the slopes are totally buried by flood deposits. If any agriculture was conducted at Pocoma following the great flood, it would have had to been "dry" farming, which would have provided only an extremely precarious subsistence.

Impact in the Ilo Valley

The devastation at the Miraflores Quebrada is impressive to say the least, but it is, however, a small irrigation system and a relatively limited area when compared to the 9 km-long irrigation system in the Ilo Valley which was also destroyed by the Miraflores Flood. All that remains of the largest irrigation canal to have ever operated in the Southern Andes is the canal support "notch" carved into solid rock and a few facing stones for the canal support walls which seem to defy gravity by clinging to the near vertical rock faces 15-20 m above the flood plain.

This agricultural system was rendered unequivocally useless by the largest single flood event yet to be identified in the Southern Andes. If any remnants of the original canal still exist, they are buried beneath countless tons of flood deposits, sheet wash, and

scree. All the higher terraces of this system are also completely buried, sometimes by as much as 10 meters or more of detritus. All flood deposits are many times greater here than those found anywhere in the coastal quebradas.

Fed additional flood materials by the lateral quebradas, the flood surge raging down the Ilo River Valley inundated everything in its path until it met the natural mud and rock dam created by the extravagant outpouring of debris from the large quebrada at Planting Surface #3. One can only imagine what the consequences would have been for the downvalley inhabitants when this "dam" breached.

Even the lower terraces are buried by flood debris that varies from 30-78 cm. Although the deposits along the river bank are normally much deeper than those found elsewhere, the overburden on the agricultural terraces in not much more than that of the terraces found in the coastal locations.

The only evidence of possible post-flood agricultural activity was one lone corn cob of the Chiribaya variety, which was found in a shovel test at Planting Surface #3. I believe that this find is an aberration because multiple shallow probes at both Planting Surfaces #1 & #2 yielded unquestionably no proof of post-flood agricultural activities in the Ilo Valley.

Evidence of the Survival or the Demise of the Chiribaya

Post-Miraflores Cultural Activity

Carrizal Quebrada

There is no direct evidence of cultural survival at the Carrizal Quebrada, but there is some indirect evidence. Since some domestic terraces at Chiribaya Baja showed no deposits from either the Chuza or the Miraflores Floods, it seems reasonable to conclude that at least some of the occupants of these terraces could have survived after the Miraflores Event. South of the domestic terrace, a 20-30 cm deep midden overrides the deposits from Miraflores in two different units. Although there is a slight mixture of pottery sherds found in these units, the overwhelming majority of them are Chiribaya, which should lead to the conclusion that there was a remnant Chiribaya population which survived the flood.

Based on recent research of prehistoric weather patterns elsewhere in Peru, there is a possibility that a drying climate may have caused the abandonment of the Carrizal Quebrada a little before the Miraflores Flood. A shrinking water supply affected the years from 1100-1300 A.D., with a marked decline beginning in 1350 A.D. or at least by 1400 A.D. (Ortloff and Kolata 1993). Other investigators state that the climate may have changed to a drier regime with below average precipitation from 1200-1500 A.D. (Thompson et al. 1985) with a severe drought occurring between 1245-1310 A.D. (Thompson et al. 1983).

Since spring-fed, localized irrigation systems are the most vulnerable to periods of drought (Ortloff and Kolata 1993), an

irrigation system, such as that used by the Chiribaya at the Carrizal Quebrada, may very well have suffered enough from a water shortage that some agricultural areas were abandoned, at least in the lower section of the quebrada. However, the upvalley irrigation system appears to have been sourced by a stream that presumably flowed during the time of the Chiribaya Culture because there is a "choke point" located meters away from a prehistoric canal 'intake". Therefore, it seems probable that this upvalley component could have remained viable until the onslaught of the Miraflores Flood.

Pocoma Quebrada

This quebrada presents more evidence supporting the hypothesis that at least some of the Chiribaya people survived the Miraflores Flood. On the high domestic terraces that lie West of the olive grove, excavations uncovered several tantalizing bits of evidence that indicate some rebuilding activities following the Miraflores Flood. The profile of the rebuilt domestic terrace wall shows that the large facing stones were set directly on top of the Miraflores deposits. Unit #2 exhibits the foundation of a cane house wall which was excavated 20 cm into Miraflores sediments. Nearby this newly constructed wall are found older, damaged canes that were presumably from a house which was razed by the flood. The 25 cm deep occupation layer gives a good indication that this location was occupied for quite some time. The segment of human pelvis bone found in this unit poses the question of whether it belonged to an occupant of the dwelling which was destroyed by Miraflores.

In another unit, there is a thick midden immediately overlying flood deposits, providing yet another confirmation of the supposition that some people at Pocoma survived the flood. Shovel testing revealed that there is another thick midden overriding the Miraflores deposits. Some of the pottery sherds found in these shovel tests were the Burro Flaco style, presumably manufactured by the former members of the Chiribaya Culture. Thirty meters from one shovel test lies the same thick occupation midden, which seems to indicate that a resident population had lived here for some time.

Probes in the several irrigation canals at Pocoma, show that at least the High Canal on the south side of the quebrada saw some limited use. It is presently inconclusive as to who used this canal following the flood, but it is obvious that a new canal was excavated into the Miraflores sediments.

The Ilo Valley

There was evidence of Post-Miraflores construction found at Planting Surface #2 (P. S. #2). The lowest terrace at this location was cleared of flood debris, and a number of rectangular cane dwellings were built. Figure 5-14 is a profile of P. S. #2 showing the location of these cane dwellings. Further activity involved the construction of a stone-lined storage pit near the houses. The limited number of houses would suggest a very small resident population, although more houses may have previously existed and have subsequently been eliminated by later flood erosion of the terrace. P. S. #2 is the only location in the entire Ilo Valley where I could find any evidence of post-flood activity by the Chiribaya people.

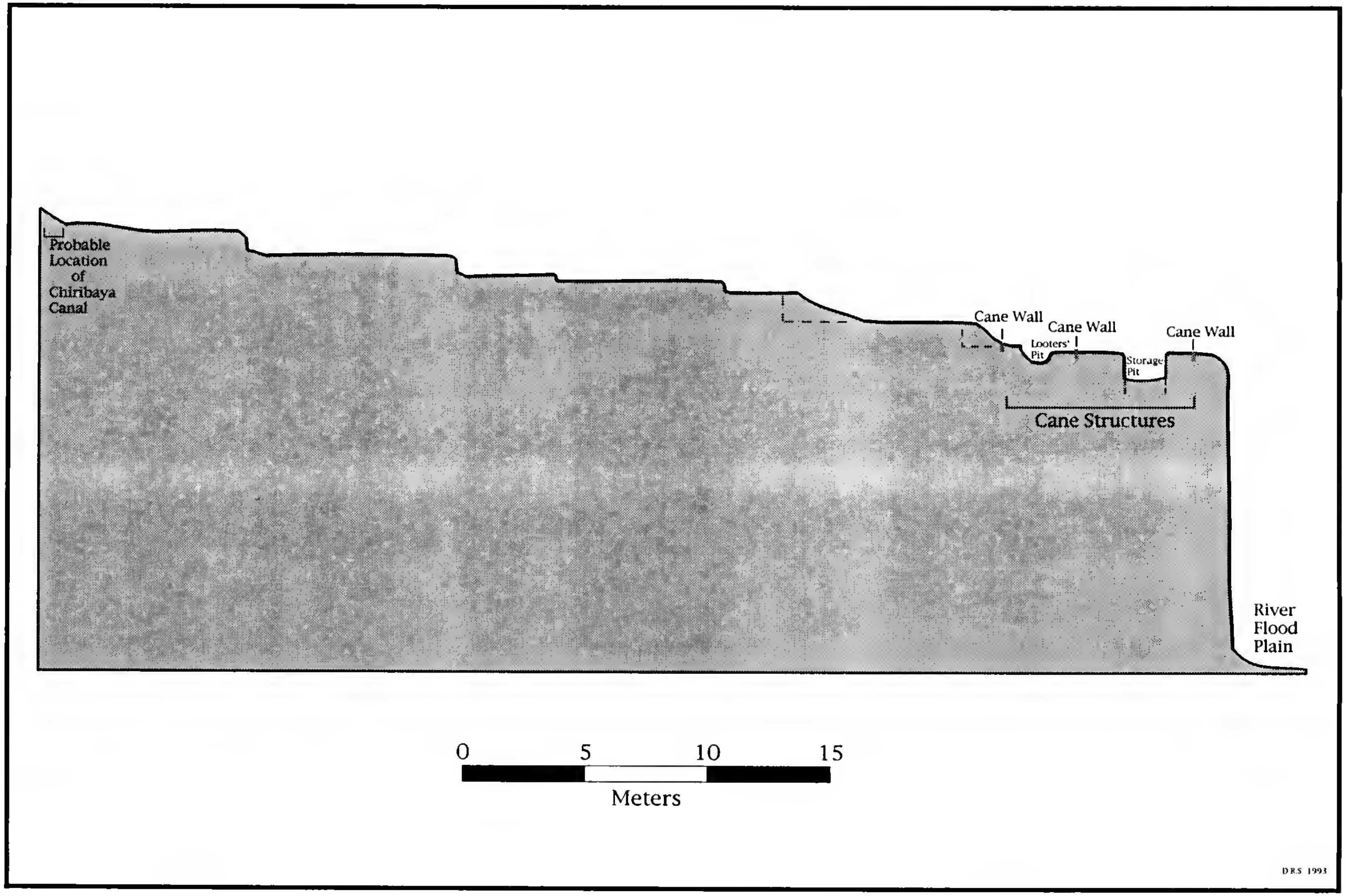


Figure 5-14: Profile of Planting Surface #2

The tomb locations associated with the planting surfaces seem to be a good indicator of whether or not these surfaces were used for agricultural purposes following the Miraflores Event. The tombs at both P. S. #1 and #2 are intrusive sepulchers excavated directly into the planting surfaces, which strongly suggests that they were never used for agricultural purposes after the decimation of the planting surfaces by the Miraflores Flood in the 14th century A.D.

Irrigated Agriculture in the Study Area

Introduction

Since much of Peru consists of a lengthy desert coast and the extremely high Andes mountains, it has inhabitable regions that are of limited size. Hence, the expanding prehistoric population was necessarily densely concentrated in small zones which were semi-isolated from each other. For this reason, the expansion of limited farming land could only be conducted efficiently on a valley-wide or regional basis (Lanning 1967:4). Coastal valleys, such as Carrizal, Miraflores, and Pocoma, North of Ilo, and the Ilo Valley were small and probably moderately densely populated areas, which could only support the resident population with the aid of extensive valley-wide irrigation systems.

Types of Terraces Used in the Study Area

Virtually all agricultural land below 3,000 m, in the Moquegua Drainage, is terraced because of the steep gradients (Stanish 1987) produced by gradual tectonic uplift and the downcutting of the watershed (Clement and Moseley 1991). My personal field survey

has determined that there are three types of terraces found in the study area along the coast and in the Ilo Valley. The first is the *Andene* or "staircase" type. These terraces usually have either vertical or slightly back-sloping facing walls of mortarless stone work. The agricultural surface itself is sometimes nearly flat, but more often the surfaces slope forward to facilitate the drainage of excess water to the lower surfaces. The "staircase" type is by far the most common terrace design used in the areas near Ilo. This terrace scheme is basically the same as that found elsewhere in Peru (Denevan 1987).

As the slope increases in steepness, "contour" terraces, which closely follow natural terrain of the steep walls of the Ilo valley and coastal quebradas, are used. These terraces are relatively narrow, varying from about 1.0 to 2.0 meters in width--in contrast to the lower terraces which may be as much as 8 meters wide. A major advantage of contour terraces is the creation of cultivable land where none normally exists. Remnants of contour terraces are found occasionally only in the coastal quebradas because the mudslides from the 14th century Miraflores flood either totally destroyed or covered all of the higher contour terraces in the Ilo Valley.

Only a very few "linear" terraces can be found anywhere in the study area. These short, rather narrow terraces tend to run laterally across the slope of the not-too-inclined hillsides (Denevan 1987). These types of terraces are only found on the north side of the quebrada at the P. S. #1, far up the Ilo Valley (Figure 5-15). Mortarless stone walls were used as supports for the agricultural terraces, and served to prevent the erosion of agricultural soils, while

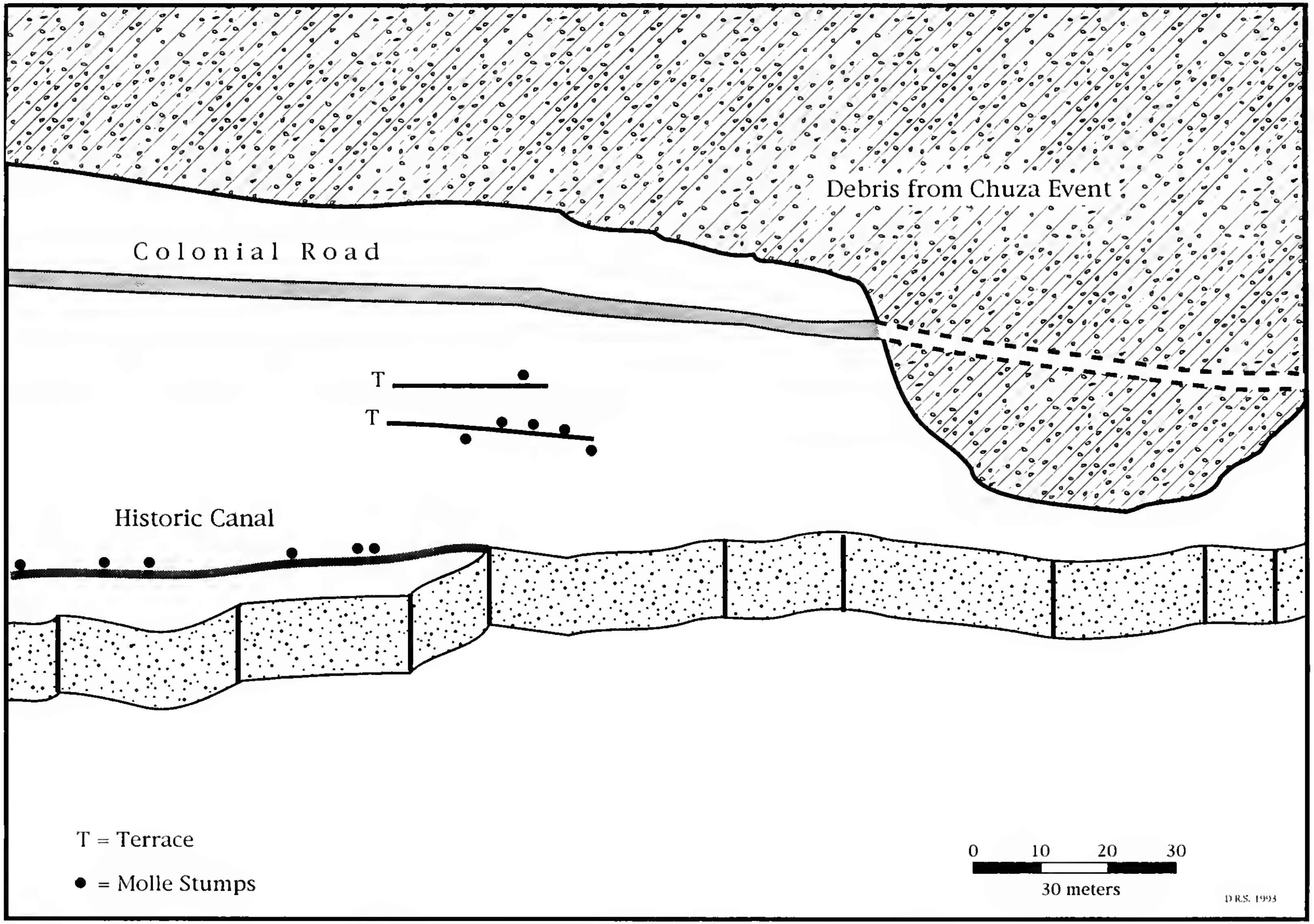


Figure 5-15: Planting Surface #1--Ilo Valley

at the same time allowing excess water to drain to the lower surfaces. This design is a sound architectural practice because the area is tectonically active, and the stone walls built using this construction technique are non-rigid and are able to move with the undulations of the earth.

Types of Canals Used in the Study Area

There are two types of prehistoric irrigation canals used in the Moquegua Drainage. In the higher elevations, where there are narrower valleys with rapid, more or less permanent streams with steep gradients, people diverted water upstream into short, "linear" canals, which would irrigate small plots of farm land. In the lower Ilo Valley, where there probably was an intermittent stream augmented by springs, the Chiribaya most likely built a "*toma rustica*" (a primitive diversion dam of stones and/or logs, which are still is use today), which raised the water level and, at the same time, diverted the water into a intake canal that fed into the main "contour" irrigation canal (*Acequia Madre*), which supplied the lateral or feeder canals that ran perpendicular to the main canal and terminated in the fields. The advantage of a contour canal, which typically is about 1° slope (or less at higher elevations, such as at Otora, Stanish 1987), is to incorporate the maximum allowable land using a river inlet as far up-valley as is feasible. Prehistoric canals, in many parts of the world, are rarely constructed to flow down slopes greater than 2 per cent because of canal erosion (Farrington 1980).

Further, a contour canal closely follows the natural terrain in order to maintain a small, constant slope as it descends farther downvalley. Similar canals are also found on the north coast of Peru, and, regardless of location and topography, all "require precise surveying skills to find the correct path" (Ortloff 1988:102). This type of construction is typical of both the Middle Horizon and the Late Intermediate Period (Ortloff 1994).

Canal construction used in the Ilo Valley and in the coastal quebradas was the same. Retaining support walls, called *Pirca* (Stanish 1987), constructed with mortarless stones were used to prevent the erosion of the outside canal wall. The inside wall of the irrigation canal, in the case of the Ilo Valley, was carved into the solid granitic slopes, leaving a canal "notch" that is frequently visible high on the sheer walls of the Ilo Valley.

Irrigation Reservoirs

Reservoirs are vital engineering components of the PreHispanic agricultural system as is evidenced by the fact that at least 5 reservoirs have been discovered in the Otora Valley. These structures were stone-lined, earthen-filled wells about 1 m wide that were placed directly on the main canal lines (Stanish 1987:344). Similar technology was used by the colonial Spanish at Carrizal, where a series of cement holding tanks migrated downslope as the phreatic level has decreased through the centuries (Clement and Moseley 1991). Earlier investigators found similar holding basins elsewhere in the highlands (Cook 1916).

In the coastal quebradas, where much of the water supply was doubtless provided by springs alone, water storage for the irrigation systems would be even more critical. The quebrada residents would need to capture and store the meager flow in a reservoir, and later open a floodgate or spillway to provide enough hydraulic pressure to allow the irrigation of the fields farthest from the water source.

Discussion

The flood impact was much less at Carrizal than it was at the Miraflores Quebrada because of the constricted quebrada that is located 2 km above the olive grove. As the quebrada opened on to a large, gently sloping terraced agricultural area (Figure 5-6D), the Miraflores Flood would have spread laterally and slowed, losing most of its forward velocity and, at the same, its capacity to carry much of its heavier sediment load. For this reason, the flood deposited hundreds of large rocks, ranging in size from 10 cm to a meter plus (Figure 5-7) over a 250 m by 600 m area of the agricultural terraces.

Geological columns show that additional flood debris continued flowing down the main quebrada channel and, when the flood encountered the canal "Choke Point," it would have risen sufficiently to destroy the canal intake. In sum, the Miraflores Event, possibly the largest El Niño flood event in the last 4,000 years (based on the fact that it overlies a Preceramic midden at the La Yara Quebrada) would have decimated the entire irrigated agricultural system of the upper Carrizal Quebrada and rendered it useless in a matter of seconds.

These exposed profiles showed the sequence of the deposition of the aeolian materials and the various floods. The depth of these deposits gives an indication of the severity of each flood episode because, as the units proceed farther downslope, the deposits should become thinner as the distance increases, as was indeed the case with the Chuza flood deposits, which, generally, would decrease in depth until, at some point, they would disappear entirely. However, the Miraflores deposits did not decrease substantially in depth, and could be found in the lowest portions of the Miraflores Quebrada, all the way to the Pacific Ocean. Since there was no evidence of the Chuza or the Miraflores Flood found on the occupation terrace at Carrizal Baja, it can be assumed the if the domestic terraces had been occupied at the time of the Miraflores Flood, the Chiribaya residents at this particular location would have survived.

CHAPTER 6
EXCAVATED DATA

Introduction

Using the methods outlined in Chapter 3 sufficient data were recovered in the locations discussed in Chapter 5 to support my original hypothesis that the Miraflores Flood, which occurred in the mid-14^{th} century A.D., had indeed destroyed the Chiribaya irrigated agricultural system beyond repair, and that this destruction had ultimately led to the demise of the Chiribaya Culture around 1350 A.D. Included in this chapter is the analysis of these data, presented in a series of tables and graphs, which conclusively prove that the Miraflores Flood was the largest single flood episode identified to date that has occurred in the Southern Andes in perhaps millennia.

Types and Quantities of Materials Expected from each Locality

Since the Chiribaya utilized pottery for centuries, it was expected that Chiribaya potsherds would be the most abundant artifacts found throughout the research area, even though there was a chance of occasionally finding another pottery style because of the interaction with the highland cultures living around Moquegua. Since "the Chiribaya pottery is the most beautiful found in the region for all epochs" (Mujica 1990:132), it is easily identified because the vibrant pottery is usually decorated with black, white,

and orange on a red base with geometric designs, such as panels with semi-circles, and red bands with white dots (Jessup 1990).

Because the Chiribaya was an agricultural based culture, domestic plant remains, such as maize, ají, coca, and gourd, were predicted to be found occasionally in the excavated units. However, these expectations would not exclude the discovery of marine remains since the exploitation of marine resources by native Peruvians has a well-documented history spanning 8,000 or more years (Bird 1938, 1946a, 1946b, 1988; Sandweiss 1989; Wise 1989, 1990), and at least ten different type of marine mollusks have been found in burials (Mujica 1990).

Since weaving generally accompanies the use of pottery and agriculture, raw materials (both cotton and camelid wool) for weaving and the concomitant necessary instruments could be represented among the recovered artifacts. However, considering the fact that the excavations were not intended to concentrate exclusively on the habitation areas, the overall frequencies of certain artifact categories probably would not be consistent with those frequencies associated with the excavations of dwellings or tombs.

The expected outcome was not always the case, especially concerning the excavations at the Miraflores Quebrada because the flood impact varied from quebrada to quebrada. For example, the results from the excavations at the Carrizal and Pocoma Quebradas were not regularly what had been anticipated because the topography of the individual quebradas differentially affected the presence of the cultural remains in the flood deposits.

Excavated Data from the Carrizal Quebrada

Table 6-1 contains the data from Unit #1 S. Although this unit is located in an irrigation canal, it contained more cultural materials than was predicted because of the proximity to a domestic terrace. Even Levels #1 & #2 (L. #1 & #2) of the mixed aeolian/organic layer contained 30 potsherds, which were mostly Chiribaya domestic ware. One lone piece of olive wood from L. #2 seems to indicate that olive trees once probably grew very close to the unit's location. The combined aeolian/Chuza L. #3 consisted of a number of bone fragments from unidentified mammals and fish vertebrae. Since vertebrae are generally larger and more durable than the other fish bones, they are usually the most common fish remains found, unless fine-mesh wet screening or "flotation" is used. Cotton fibers in this level are not an unusual find since the Gossypium barbadense variety of cotton has been a domesticated plant in Peru since the Preceramic Period (Moseley 1992). The presence of lithic flakes in an historical level would normally be difficult to explain, since lithic tools have not been commonly used for several millennia. However, whenever a culture's subsistence base is destroyed, people will often re-adapt an abandoned technology in order to guarantee the culture's existence. Excavations at the possible Post-flood site of Burro Flaco have discovered thousands of lithic flakes and a number of stone tools, including hunting/fishing points, conceivably manufactured and utilized after the destruction of the Chiribaya agricultural base by the Miraflores Event. During the centuries between the Miraflores

Table 6-1: Excavated Data from Carrizal Quebrada

Unit #1 South	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Fish Bones	Olive Wood	Raw Cotton	Carbon	Textile Frag
Level #1 0-10 cm.	Aeolian/ Organic	2	10.12									
Level #2 10-20 cm.	Aeolian/ Organic	28	83.34						Yes			
Level #3 20-30 cm.	Organic/ Chuza	52	370.05		Yes	None	Yes	Yes		Yes	Yes	1
Level #4 30-40 cm.	Chuza/ Aeolian	88	531.20									
Level #5 40-50 cm.	Aeolian/ Miraflores	11	51.04				Yes					
Level #6 50-60 cm.	Miraflores	15	74.90				Yes				Yes	
Level #7 60-70 cm.	Miraflores	4	20.08				Yes				Yes	D.R.S. 1993

and Chuza Floods, aeolian deposits accumulated to form L. #4 & #5. With the exception of one small unidentified mammal bone, no other artifacts were found in these units. L. #6 & #7 were located in the Miraflores deposits, and nothing but a few unknown mammal bones were uncovered, which came as a surprise since past experience with the Miraflores deposits in the Ilo Valley demonstrated that they habitually contained no artifactual remains whatsoever (Satterlee 1991).

Table 6-2 lists the artifacts from Unit #2 S., which is also located in the irrigation canal. L. #1 and #2 exhibited less than half as many sherds as did these same levels in U. #2 S. The reason for the presence of fewer sherds here is the fact that the domestic terrace in front of this unit probably prevented much of the Chuza Flood from washing as many sherds from the domestic area into the canal as the flood did into U. #1. Again olive wood and a few unidentified animal bones were found in the aeolian levels. The olive wood is to be expected since olives have been grown in the Ilo area for over 400 years. The burned organic layer found in L. #3 and #4 could have possibly come from the burning of agricultural refuse in an effort to create potash for additional fertilizer for agriculture. The abundant seashell fragments probably were the remains from marine comestibles, which, when burned, can also serve as fertilizer. L. #4, #5, and #6 are also void of any cultural materials also because the Chuza Flood did not breech the domestic terrace.

Table 6-2: Excavated Data from Carrizal Quebrada

Unit #2 South	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Human Bones	Guinea Pig Bones	Olive Wood	Carbon	Textile Frag
Level #1 0-10 cm.	Aeolian	4	13.30							Yes		
Level #2 10-20 cm.	Aeolian	14	53.00				Yes			Yes		
Level #3 20-30 cm.	Burned Organic	10	55.60	Many Frags				1				
Level #4 30-40 cm.	Burned Organic	3	46.20	Many Frags			Yes		Yes			
Level #5 40-50 cm.	Chuza	0	0.0									
Level #6 50-60 cm.	Chuza	0	0.0									
Level #7 60-70 cm.	Chuza	0	0.0									D.R.S. 1993

Table 6-3 lists the artifacts from Unit #3 S., which lies directly on the domestic terrace above the irrigation canal. L. #1 contained dozens of colonial potsherds as would might be expected for a level this close to the surface. L. #2 and #3 had an abundance of potsherds because the agricultural activities present in these levels were conducted on occupational debris which had probably been spread down slope from the nearby terrace. The occupation midden represented by L. #4, #5, #6, and #7 naturally contains 29% more Chiribaya sherds than does the mixed aeolian/agricultural stratum because the midden represents an area of concentrated human activity. The unknown mammal bones, fish vertebrae, and one sea mammal (Lobo marino) bone are all probably refuse from eating. The drilled sherd pendant might be expected to be found in an occupation midden, but a human phalange is not necessarily an anticipated find.

Table 6-4 lists the artifacts from Unit #4 S., which was located a few meters South of the domestic terrace and, therefore, it contained fewer pottery sherds than did the other units discussed thus far. L. #1 and #2 of the aeolian stratum contained only 5 colonial sherds and a little olive wood from historical olive grove tending. L. #3 and #4, located in the Chuza deposits, also included few artifactual remains, which were 8 sherds, a little olive wood, and, once again, a lithic flake, which probably originates from the later Burro Flaco Phase. L. #5 in the Chuza Flood and L. #6 and #7 in the Miraflores Flood were totally barren of cultural materials.

Table 6-3: Excavated Data from Carrizal Quebrada

Unit #3 South	Deposits are:	Sherds	Weight in Grams	Marine Shells	Maize Kernal	Unknown Mammal Bones	Fish Bones	Sea Mammal Bone	Human Bones	Drilled Sherd Pendant
Level #1 0-10 cm.	Aeolian	29	166.00		1					
Level #2 10-20 cm.	Aeolian/ Agric.	36	303.50							
Level #3 20-30 cm.	Aeolian/ Agric.	5	25.80							
Level #4 30-40 cm.	Midden	28	242.00			Few	Yes	1		
Level #5 40-50 cm.	Midden	48	388.40						1	1
Level #6 50-60 cm.	Midden	18	154.20							
Level #7 60-70 cm.	Midden	4	32.80							

D.R.S. 1993

Table 6-4: Excavated Data from Carrizal Quebrada

Unit #4 South	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Fish Bones	Olive Wood	Raw Cotton	Carbon	Textile Frag
Level #1 0-10 cm.	Aeolian	2	8.80									
Level #2 10-20 cm.	Aeolian	3	20.03						Some			
Level #3 20-30 cm.	Chuza	4	25.80									
Level #4 30-40 cm.	Chuza	4	19.1		1				Some			
Level #5 40-50 cm.	Chuza	0	0.0									
Level #6 50-60 cm.	Miraflores	0	0.0									
Level #7 60-70 cm.	Miraflores	0	0.0									D.R.S. 1993

Table 6-5 lists the artifacts found in Unit #5 S., located below the irrigation canal, which contained a moderate number of sherds apparently washed downslope by the mudflows. L. #1 located in the aeolian layer contained only historic sherds. L. #2 in the upper Chuza deposits also had historic sherds, with the exception of one possible Burro Flaco sherd. Included in L. #2 were 3 human bones which possibly were from disturbed tombs located immediately to the South of this unit. L. #3 had two more sherds than the previous level, and also included a few fish vertebrae, 2 human bones, some carbon, and a little copper ore. There is nothing significant about this level, including the copper ore since we know for certain that at the Burro Flaco Site people were smelting copper and casting it in the form of harpoon barbs (Penmann and Bawden 1991). In L. #4 the number of sherds decreases significantly because this level is located in the upper Miraflores sediments. Some copper ore was also found in this level, but its presence signifies nothing special. L. #5, #6, and #7 were not excavated because of the large rocks (up to 30 cm) contained in the Miraflores deposits. Marine shells were quite numerous in all the levels of the Chuza deposits because, following the Miraflores Flood, there seems to have been a substantial increase in the exploitation of marine resources to help replace the loss of the agrarian resources.

Table 6-6 lists the artifacts found in Unit #6 S., which contained more sherds than any other previous unit possibly because of the midden and the neighboring disturbed tombs. L. #1,

Table 6-5: Excavated Data from Carrizal Quebrada

Unit #5 South	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Fish Bones	Human Bones	Copper Ore	Carbon	Textile Frag
Level #1 0-10 cm.	Aeolian	19	71.50	Many								
Level #2 10-20 cm.	Chuza	39	355.30	Many					3			
Level #3 20-30 cm.	Chuza	41	539.60	Many				Few	2	Yes	Yes	
Level #4 30-40 cm.	Miraflores	10	91.20	Yes						Yes		
Level #5 40-50 cm.	Not Excavated											
Level #6 50-60 cm.	Not Excavated											
Level #7 60-70 cm.	Not Excavated											D.R.S. 1993

Table 6-6: Excavated Data from Carrizal Quebrada

Unit #6 South	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Fish Bones	Copper Fishing Weight	Chert	Carbon	Textile Frag
Level #1 0-10 cm.	Agric.	25	115.00	Some				Yes				
Level #2 10-20 cm.	Midden	37	172.50	Some			Yes			Yes		
Level #3 20-30 cm.	Midden	142	1410.30	Some			Yes	Yes	1	Yes		
Level #4 30-40 cm.	Miraflores	0	0.0									
Level #5 40-50 cm.	Miraflores	0	0.0									
Level #6 50-60 cm.	Not Excavated											
Level #7 60-70 cm.	Not Excavated											D.R.S. 1993

which showed evidence of agriculture, was probably the upper limit of the midden since this level contained several dozen sherds and some fish vertebrae. L. #2 and #3 both had unknown mammal bones and some pieces of chert. L. #3 had more sherds than did the level directly overlying it. The fish vertebrae found in L. #3 are also a good indication of exploitation of marine resources, but an even better indicator of the return to a fishing subsistence following the Miraflores Flood was the copper fishing weight found in L. #3. The presence of storage pits containing many small dried fish in the excavations at San Geronimo conducted by Jessup (1990, 1991), also supports the proposition of a maritime subsistence after the Miraflores Flood. L. #1, #2, and #3 all contained some marine shells, whose presence reinforces the hypothesis that by now the Chiribaya were probably mainly a fishing society, much like their Archaic Period ancestors, with perhaps some dependence on dry farming. L. #4 and #5 in the Miraflores deposits contained absolutely nothing.

Excavated Data from Miraflores Quebrada

Table 6-7 lists the artifacts found in Unit #1 N., one of seven units excavated between the previously described sunken features at Miraflores Quebrada. The aeolian deposits of L. #1 contained only one very small potsherd of probable historic origin. The camelid wool was a rather unusual find since llama or alpaca are only rarely brought from the highlands to the coast to graze in the Lomas, when they experience a rich "bloom," and the last such

Table 6-7: Excavated Data from Miraflores Quebrada

Unit #1 North	Deposits are:	Sherds	Weight in Grams	Native Ore	Camelid Wool	Unknown Mammal Bones	Fish Bones	Olive Wood	Molle Wood	Slag	Cane
Level #1 0-10 cm.	Aeolian	1	.26		Yes			Yes	Yes		Yes
Level #2 10-20 cm.	Chuza	1	.18	Galena		Yes			Yes	Yes	
Level #3 20-30 cm.	Chuza	0	0.0	Copper		Yes			Yes		
Level #4 30-40 cm.	Chuza	0	0.0	Arsenic							
Level #5 40-50 cm.	Miraflores	0	0.0								
Level #6 50-60 cm.	Miraflores	0	0.0								
Level #7 60-70 cm.	Miraflores	0	0.0								D.R.S. 1993

phenomenon occurred in 1982-83. Remnants of olive and Molle wood are fairly common finds in the region since olive trees are domesticated, and Molle trees are ordinarily found growing in many locations. L. #2 in the Chuza deposits also had only one small sherd, a few unidentifiable mammal bones, and some Molle wood. However, this level does exhibit some possible evidence of historic smelting of ores, because both galena ore and some slag were found in this quebrada. Although L. #3. contained no pottery, it did have a few mammal bones and a little Molle wood. The fact that some copper ore was found in this level could be another indicator of smelting activities. Were the copper ore contained within the deposits of the prehistoric Miraflores Flood, rather than the historic Chuza Flood, its presence might bear some significance since the site of Burro Flaco contains the first hard evidence of smelting of ores in the Ilo area. L. #4 had only one small piece of arsenic, which can be used in the production of arsenical bronze. L. #5, #6, and #7 reside in the Miraflores deposits and were totally void of any remains.

Table 6-8 lists the artifacts contained in Unit #2 N. L. #1 is an aeolian layer which contained no pottery, but it had some unidentifiable plant remains, undoubtedly of historic origin, and some copper ore. The most interesting find in this level was yellow and red ochre, which was found in the bottom of L. #1 and in the top of L. #2 in the Chuza deposits. Both of these substances are often used for religious purposes or for burials. L. #2 had no pottery, but it did contain some camelid wool, slag, and small bits of carbon. Marine shells first appear in L. #3, which also contained

Table 6-8: Excavated Data from Miraflores Quebrada

Unit #2 North	Deposits are:	Sherds	Weight in Grams	Marine Shells	Camelid Wool	Unknown Plant Remains	Native Ore	Daub	Red/ Yellow Ochre	Slag	Carbon
Level #1 0-10 cm.	Aeolian	0	0.0			Yes	Copper		Yes		
Level #2 10-20 cm.	Chuza	0	0.0		Yes					Yes	Yes
Level #3 20-30 cm.	Chuza	0	0.0	Few				Yes		Yes	
Level #4 30-40 cm.	Miraflores	0	0.0								
Level #5 40-50 cm.	Miraflores	0	0.0							Yes	
Level #6 50-60 cm.	Miraflores	0	0.0								
Level #7 60-70 cm.	Not Excavated										D.R.S. 1993

some more slag, and some daub, which probably came from one of the Chincha --daub and waddle--cane dwellings, commonly used by the Chiribaya people. L. #4 was a typically disappointing Miraflores level, since it contained nothing. L. #5 did have a small piece of slag, but this find is somewhat suspect, since no other slag was found in any other levels in the Miraflores deposits. L. #6 contained nothing, and so excavations were ended here.

Table 6-9 lists the artifacts found in Unit #3 N. L. #1 contained only one historic sherd and a small bit of carbon. Chuza deposits began in the lower part of L. #1 and composed all of L. #2, which had some burned shells and a small amount of raw cotton, which grows wild in the Ilo Valley, but not in the coastal quebradas. L. #3 contained two onions, which was one of the domesticated crops, including olives and grapes, that were introduced into the area by the 16th century Spanish (Kuon Cabello 1985). L. #4 in the Miraflores sediments contained a small bit of carbon. L. #5, had one worked terrace facing stone, which could have come from either a domestic or an agricultural terrace. L. #6, and #7, in these same deposits held naught.

Table 6-10 lists the contents of Unit #4 N. L. #1, the aeolian layer contained no pottery, but did have some carbon and a little red ochre. L. #2 is a mixed aeolian/Chuza layer, with no sherds, that also contained both red ochre, carbon, plus one olive leaf. L. #3 in the Chuza deposits had a few shell fragments, a little carbon, and some sulphur. What was interesting is the fact that this level and

Table 6-9: Excavated Data from Miraflores Quebrada

Unit #3 North	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Plant Remains	Fish Bones	Olive Wood	Raw Cotton	Carbon	Terrace Stone
Level #1 0-10 cm.	Aeolian	1	.57								Yes	
Level #2 10-20 cm.	Chuza	0	0.0	Burned						Yes		
Level #3 20-30 cm.	Chuza	0	0.0				Two Onions					
Level #4 30-40 cm.	Miraflores	0	0.0								Yes	
Level #5 40-50 cm.	Miraflores	0	0.0									1
Level #6 50-60 cm.	Miraflores	0	0.0									
Level #7 60-70 cm.	Miraflores	0	0.0									D.R.S. 1993

Table 6-10: Excavated Data from Miraflores Quebrada

Unit #4 North	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Fish Bones	Plant Remains	Red Ochre	Carbon	Native Minerals
Level #1 0-10 cm.	Aeolian	0	0.0							Yes	Yes	
Level #2 10-20 cm.	Aeolian/ Chuza	0	0.0						Olive Leaf	Yes	Yes	
Level #3 20-30 cm.	Chuza	0	0.0	Frags					One Onion		Yes	Sulphur
Level #4 30-40 cm.	Miraflores	1	0.46									
Level #5 40-50 cm.	Miraflores	0	0.0									
Level #6 50-60 cm.	Miraflores	0	0.0	Few Frags								
Level #7 60-70 cm.	Not Excavated											D.R.S. 1993

its counterpart in Unit #3 both contained onions. Did these onions come from a small garden plot near the house in the olive grove, or did they come from a garden patch planted on the richer soil of the former Chiribaya village? Only more extensive investigation can answer these questions. L. #4 had one small, black on beige Chiribaya sherd. As usually is the case, the lower levels, L. #5 and #6, produced nothing of interest except a few shell fragments.

Table 6-11 lists the contents of Unit #5 N., which contained more cultural materials than the combined totals of the other six units between the sunken features. Some carbon and a few pieces of red ochre were found the aeolian L. #1. Also included in L. #1 was one coca leaf (Erythroxylon coca), and a piece of thread spun from alpacawool. The mixed aeolian/Chuza layer, L. #2, held 7 sherds, the only ones found in the entire unit. In addition to some unknown mammal bones and strands of human hair, this unit produced some spun alpacawool thread, and small lengths of spun cotton thread and cord, like that used by fisher folk. One of the few dyed items found was the bright red yarn ear ornament used to decorate camelids, especially llama during special festivals. After all of these items in L. #2, L. #3 proved to be somewhat of a disappointment, since it contained only one small cane fragment. The Miraflores deposits of L. #4 held only a piece of wood that could only be tentatively classified as Molle, since it is so common in the region. L. #5 had no pottery, but it contained a small piece of metal that appeared to be a small piece of intrusive iron since the Eskimo were the only native Americans to use iron. If this

Table 6-11: Excavated Data from Miraflores Quebrada

Unit #5 North	Deposits are:	Sherds	Weight in Grams	Coca Leaf	Spun Alpaca Wool	Spun Cotton	Unknown Mammal Bones	Human Hair	Wood	Red Ochre	Carbon	Native Mineral
Level #1 0-10 cm.	Aeolian	0	0.0	1	3 cm. Piece of Thread					Yes	Yes	
Level #2 10-20 cm.	Aeolian/ Chuza	7	31.45		Thread/ Alpaca Ear Ornament	Thread & Cord	Yes	Yes				
Level #3 20-30 cm.	Chuza	0	0.0								Cane	
Level #4 30-40 cm.	Miraflores	0	0.0						Molle?			
Level #5 40-50 cm.	Miraflores	0	0.0									Iron?
Level #6 50-60 cm.	Miraflores	0	0.0									
Level #7 60-70 cm.	Not Excavated											D.R.S. 1993

identification is correct, this find would be one of the few instances where metal has been found in a Chiribaya context. The culture normally relied on pottery and wooden implements, although some metal body decorations have been found in tombs. L. #6 contained nothing but flood deposits.

Table 6-12 lists the meager contents of Unit #6 N. L. #1, again an aeolian layer, held only a small amount of mixed carbon, which was of no use for analysis. The mixed aeolian/Chuza layer L. #2 had only a few shell fragments. L. #3, located entirely in the Chuza sediments, contained a small piece of olive wood. L. #4 also had a piece of wood, but it must have been Molle since this level was in the Miraflores Flood. L. #5 only had a few shell fragments and nothing else. L. #6 was totally void of anything of a useful nature.

Table 6-13 lists the contents of Unit #7 N., which is the northernmost unit of the series of units between the large features. L. #1, the aeolian component, contained a few marine shells and nothing else. L. #2, in the mixed aeolian/Chuza layer, held the one historic sherd, the only potsherd found in this entire unit. L. #3 had only one shell. L. #4 was located in a composite Chuza/Miraflores stratum and only contained one shell fragment, as did L. #5 and #6. Nothing of any significance was noticed in this entire unit.

Table 6-14 lists the contents of Unit #1 W., which was one of the units located along the East-West transect to the Pacific Ocean. L. #1 was a mixed layer of aeolian deposits with the last 8 cm being

Table 6-12: Excavated Data from Miraflores Quebrada

Unit #6 North	Deposits are:	Sherds	Weight in Grams	Shell	Spun Alpaca Wool	Spun Cotton	Unknown Mammal Bones	Human Hair	Wood	Red Ochre	Carbon	Native Mineral
Level #1 0-10 cm.	Aeolian	0	0.0								Mixed	
Level #2 10-20 cm.	Aeolian/ Chuza	0	0.0	Frags								
Level #3 20-30 cm.	Chuza	0	0.0						Olive			
Level #4 30-40 cm.	Miraflores	0	0.0						Molle?			
Level #5 40-50 cm.	Miraflores	0	0.0	Frags								
Level #6 50-60 cm.	Miraflores	0	0.0									
Level #7 60-70 cm.	Not Excavated											D.R.S. 1993

Table 6-13: Excavated Data from Miraflores Quebrada

Unit #7 North	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Fish Bones	Olive Wood	Raw Cotton	Carbon	Textile Frag
Level #1 0-10 cm.	Aeolian	0	0.0	Few								
Level #2 10-20 cm.	Aeolian/ Chuza	1	0.23	Few								
Level #3 20-30 cm.	Chuza	0	0.0	1								
Level #4 30-40 cm.	Chuza/ Miraflores	0	0.0	Few Frags								
Level #5 40-50 cm.	Miraflores	0	0.0	1 Frag								
Level #6 50-60 cm.	Miraflores	0	0.0	1 Frag								
Level #7 60-70 cm.	Not Excavated											D.R.S. 1993

Table 6-14: Excavated Data from Miraflores Quebrada

Unit #1 West	Deposits are:	Sherds	Weight in Grams	Coca Leaf	Maize Remains	Unknown Mammal Bones	Fish Bones	Olive Wood	Spun Cotton	Raw Cotton	Metals
Level #1 0-10 cm.	Aeolian/ Chuza	36	191.30					Yes	Thread		Copper/ .6 gms.
Level #2 10-20 cm.	Chuza	0	0.0							Yes	Copper/ .2 gms.
Level #3 20-30 cm.	Chuza	0	0.0	1	Yes						
Level #4 30-40 cm.	Miraflores	0	0.0		Yes						
Level #5 40-50 cm.	Miraflores	0									
Level #6 50-60 cm.	Miraflores	1	0.28								
Level #7 60-70 cm.	Miraflores	0	0.0								D.R.S. 1993

Chuza sediments. For a stratum in a unit at Miraflores Quebrada, this layer was relatively rich with sherds (36) and further it contained some olive wood, a piece of cotton thread and a very small piece of copper (.6 gm.), and all were of historic vintage. There is no real explanation for the presence of so many sherds since it is also situated on a domestic terrace. Perhaps the area between the sunken pits were kept clean as is often the case concerning specialized cultural locations. L. #2 in the Chuza deposits held no pottery, but it did have a little raw cotton and an even smaller bit of copper (.2 gm.). L. #3 yielded one coca leaf and a corn stalk, which was one of the few pieces of agrarian refuse found at Miraflores Quebrada. L. #4 is the beginning of the Miraflores deposits, and it also contained a piece of corn stalk. L. #5 was barren. L. #6 had one small Chiribaya sherd, which was an exciting find at this depth. L. #7 contained nothing.

Table 6-15 lists the contents of Unit #2 W. The aeolian layer, L. #1, contained the only 2 sherds, which were colonial, found in this unit. L. #2, a mixed layer of aeolian and Chuza deposits, had one coca leaf, some alpacawool, and one cotton seed, all of which would be historic. L. #3 in the Chuza deposits contained more than the other levels of this unit, i.e. a bit of corn husk, some unknown mammal bones, a few fish vertebrae, some unspun alpacawool, a little carbon, and a few cane fragments, which probably came from a domestic dwelling. L. #4 also had some cane fragments and a piece of corn stalk. L. #5, #6, and #7, located in the Miraflores deposits contained no remains.

Table 6-15: Excavated Data from Miraflores Quebrada

Unit #2 West	Deposits are:	Sherds	Weight in Grams	Maize Remains	Coca Leaf	Lithic Points	Unknown Mammal Bones	Fish Bones	Alpaca Wool	Cotton Seed	Carbon	Cane Frags
Level #1 0-10 cm.	Aeolian	2	1.24									
Level #2 10-20 cm.	Aeolian/ Chuza	0	0.0		1				Yes	Yes		
Level #3 20-30 cm.	Chuza	0	0.0	Yes			Yes	Yes	Yes		Yes	Yes
Level #4 30-40 cm.	Chuza	0	0.0	Yes								Yes
Level #5 40-50 cm.	Miraflores	0	0.0									
Level #6 50-60 cm.	Miraflores	0	0.0									
Level #7 60-70 cm.	Miraflores	0	0.0									D.R.S. 1993

Table 6-16 lists the contents of Unit #3 W. The aeolian deposits, L. #1, had only some Molle wood. The mixed aeolian/Chuza level, L. #2, had a small piece of spun alpacayarn. L. #3 contained some Molle wood and a few chunks of tar. The latter find was a rarity at this quebrada, although the Colonial Spanish commonly used tar to seal the large shipping jars which contained olive oil or wine (Smith 1991). The Chuza/Miraflores L. #4 had a small piece of olive wood, while L. #5 and #6 contained no artifactual remains.

Table 6-17 clearly shows L. #1-#5 of Unit #4 W. contained no artifactual remains. The probable reason for this lack of any cultural residue is the fact that there are no Chuza deposits present in this unit, and the fact that this unit is located a few meters from the edge of the 30 m deep quebrada. Further, there is a slight rise in elevation from the other units to the location of Unit #4 W.

Table 6-18 lists the remains found in Unit #5 W., which was purposely located in a small depression which was considered a prime location where artifacts might collect. Unfortunately, since the Chuza Flood deposits were lacking, the remains collected were few. L. #1, a mixed aeolian/Miraflores layer produced nothing. L. #2 did hold some significant remains. Besides the carbon, which will be useful for dating the Miraflores Event, burned shell and red ochre were also found. These latter two items are often used in important religious ceremonies and also in interments. Even though

Table 6-16: Excavated Data from Miraflores Quebrada

Unit #3 West	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Spun Alpaca Wool	Wood	Raw Cotton	Carbon	Tar
Level #1 0-10 cm.	Aeolian	0	0.0						Molle			
Level #2 10-20 cm.	Aeolian/ Chuza	0	0.0					Yarn				
Level #3 20-30 cm.	Chuza	0	0.0						Molle			Yes
Level #4 30-40 cm.	Chuza/ Miraflores	0	0.0						Olive			
Level #5 40-50 cm.	Miraflores	0	0.0									
Level #6 50-60 cm.	Miraflores	0	0.0									
Level #7 60-70 cm.	Not Excavated											D.R.S. 1994

Table 6-17: Excavated Data from Miraflores Quebrada

Unit #4 West	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Fish Bones	Olive Wood	Raw Cotton	Carbon	Textile Frag
Level #1 0-10 cm.	Aeolian/ Miraflores	0	0.0									
Level #2 10-20 cm.	Miraflores	0	0.0									
Level #3 20-30 cm.	Miraflores	0	0.0									
Level #4 30-40 cm.	Miraflores	0	0.0									
Level #5 40-50 cm.	Miraflores	0	0.0									
Level #6 50-60 cm.	Not Excavaated											
Level #7 60-70 cm.	Not Excavaated											D.R.S. 1993

Table 6-18: Excavated Data from Miraflores Quebrada

Unit #5 West	Deposits are:	Sherds	Weight in Grams	Burned Shell	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Fish Bones	Olive Wood	Red Ochre	Carbon	Textile Frag
Level #1 0-10 cm.	Aeolian/ Miraflores	0	0.0									
Level #2 10-20 cm.	Miraflores	0	0.0	Yes						Yes	Yes	
Level #3 20-30 cm.	Miraflores	0	0.0									
Level #4 30-40 cm.	Miraflores	0	0.0								Yes	
Level #5 40-50 cm.	Miraflores	0	0.0								Yes	
Level #6 50-60 cm.	Miraflores	0	0.0									
Level #7 60-70 cm.	Not Excavated											D.R.S. 1993

it cannot be conclusively proven at this time, I firmly believe that the large rectangular, sunken features at this quebrada were used for religious purposes, and, perhaps, for express secular purposes, as well. Besides humans rarely expend such energy to create large 2 meter deep holes with smooth clay floors just to occupy their idle hours. Sunken features, such as courts and attendant smaller pits, have been used for such cultural purposes for millennia along the Peruvian coast (Moseley 1992) and in the highlands (Manzanilla 1992). L. #3 was barren. L. #4 and #5 both contained small amounts of carbon for future ^{14}C dating. L. #6 was void of any artifactual remains.

Table 6-19 list the contents of Unit #6 W. This last unit excavated into the flood deposits at Miraflores, was located far enough upslope to again encounter the Chuza Flood deposits. L. #1, a mixed aeolian/Chuza level contained only a small amount of unspun alpacawool. L. #2, in the Chuza deposits, had some burned shell and a little carbon. L. #3 held identical remains, plus some Molle wood. L. #4, the last stratum of the Chuza deposits, had no cultural refuse. L. #5 was into the upper Miraflores sediments and contained nothing.

Tables 20A and 20B list the contents of the 2 by 2 m test probe in the east wall of rectangular feature, Pit #1. This unit was by far the most beneficial and interesting of all the units dug at the Miraflores Quebrada. Since I was excavating such a large sloping area, natural strata were used instead of the arbitrary 10 cm levels.

Table 6-19: Excavated Data from Miraflores Quebrada

Unit #6 West	Deposits are:	Sherds	Weight in Grams	Burned Shell	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Alpaca Wool	Wood	Raw Cotton	Carbon	Textile Frag
Level #1 0-10 cm.	Aeolian/ Chuza	0	0.0					Yes				
Level #2 10-20 cm.	Chuza	0	0.0	Yes							Yes	
Level #3 20-30 cm.	Chuza	0	0.0	Yes					Molle		Yes	
Level #4 30-40 cm.	Chuza	0	0.0									
Level #5 40-50 cm.	Miraflores	0	0.0									
Level #6 50-60 cm.	Not Excavated											
Level #7 60-70 cm.	Not Excavated											D.R.S. 1993

Table 6-20A: Excavated Data from Miraflores Quebrada

E. Wall Pit #1	Deposits are:	Sherds	Weight in Grams	Marine Shells	Spun Alpaca Wool	Raw Alpaca Wool	Human Bones	Fish Bones	Guinea Pig Bones	Raw Cotton	Carbon	Chribaya Textile Frags
Natural Stratum Used.	Aeolian	0	0.0									
Natural Stratum Used.	Chuza	2	7.95	Yes							Yes	
Natural Stratum Used.	Huayna Putina Ash	0	0.0									
Natural Stratum Used.	Miraflores	7	29.10	Yes	S-Spun Dyed Thread/ Cord	Yes	1	Yes	Yes	Yes	Yes	4
												B.R.S. 1993

Table 6-20B: Excavated Data from Miraflores Quebrada

E. Wall Pit #1	Deposits are:	Rabbit Bones	Unknown Mammal Bones	Unknown Plant Remains	Maize Remains	Coca Leaf	Cane	Sheep Wool	Coprolite	Unknown Bird Feathers	Tar
Natural Stratum Used.	Aeolian										
Natural Stratum Used.	Chuza			Yes				Yes	Unknown Mammal		Yes
Natural Stratum Used.	Huayna Putina Ash										
Natural Stratum Used.	Miraflores	Yes	Yes	Yes	Stalk/ 1 Cob	1	Yes			Yes	
											D.R.S. 1993

Nothing was found in the Aeolian stratum, which was 8 cm thick. The Chuza stratum contained 2 historic potsherds, some marine shells, a few unknown plant remains, a little sheep wool, an unidentified coprolite from a small mammal, a few chunks of tar, and some carbon. In the Chuza deposits, there was a carbonized layer 9 cm high by 40 cm long, which had been subjected to some fairly high temperatures because the flood deposits had changed color. A similar burned area was found in Unit #2 N., and in Unit #4 N., a 25 cm by 20 cm burned area was also found. It is unclear whether these areas were the results of domestic hearths or some other undetermined source.

As expected, the Huayna Putina ash stratum had no artifactual materials. The Miraflores deposits contained a number of remains, which included: 7 Chiribaya potsherds, which included 2 pieces of painted bowls (*Chua*), some marine shells, a piece of human rib, fish vertebrae, Guinea Pig (*Cuy*) bones, rabbit bones, some unknown mammal bones, some unidentified plant remains, and one corn stalk and one corn cob. All of these materials are more than likely related to cooking and eating activities, which could also account for the carbon found in the sediments. One piece of cane, presumed to be from a domestic structure, was also included in the Miraflores deposits. A number of the recovered remains were probably related to weaving activities. For example, both raw alpaca wool and cotton were found. Finished woven products included some S-spun dyed alpaca thread and cord, and 4 textile fragments.

The only remains found that could be interpreted as being used for religious purposes were several unidentified bird feathers and 1 coca leaf. Fortunately, these cultural remains had been preserved by the depth and east wall of the sunken pit. There were also a number of large stones that could have come from an exterior wall or from a seating bench, that could have sat about 15 cm above the floor and had a depth of 11 cm, based on the analysis of the remains. This premise is based on the fact that there were a number of rock imprints (18 cm above the level of the floor) left in the well-preserved worked clay found at the east edge of this sunken feature. These pieces of clay were obviously not part of the 12 cm thick clay floor which the pit had. In sum, the large chunks of clay and the many worked stones leave the impression that there could have been a "wall-fall," which also helped preserve these cultural materials.

Table 6-21 lists the contents of the 1 m by 2 m Trench #1 at the very edge of the marine terrace where it slopes down to the ocean. L. #1, #2, and #3 contained nothing except some root hairs, which extended down to 20 + cm. L. #5, #6, and #7 contained nothing. The only significant remains found in the unit were three terrace stones included in L. #4. The fact that these stones were carried from the terraces 400 + m upslope, once again emphasizes the strength of the mudflow caused by the Miraflores Event.

Table 6-21:Excavated Data from Miraflores Quebrada

Trench #1	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Fish Bones	Olive Wood	Raw Cotton	Carbon	Terrace Stones
Level #1 0-10 cm.	Aeolian	0	0.0									
Level #2 10-20 cm.	Miraflores	0	0.0									
Level #3 20-30 cm.	Miraflores	0	0.0									
Level #4 30-40 cm.	Miraflores	0	0.0									3
Level #5 40-50 cm.	Miraflores	0	0.0									
Level #6 50-60 cm.	Miraflores	0	0.0									
Level #7 60-70 cm.	Miraflores	0	0.0									D.R.S. 1993

Excavated Data from Pocoma Quebrada

Table 6-22 lists the contents of Unit #1. which was located on a prehistoric domestic terrace, it had subsequently been used as an historic agricultural terrace, and, thus, was disturbed. L. #1 was a shallow aeolian layer that contained only some marine shell. The Miraflores deposits found in L. #2 had a few shells and no other cultural remains. L. #3, #4, and #5, also in the Miraflores deposits, did not even contain shell fragments. Apparently the Miraflores Flood totally inundated and swept any cultural debris from this terrace.

Table 6-23 lists the artifacts found in G. C. #1 which contained five natural strata exposed by the excavation done with heavy equipment. Ten cm were cleaned inward from the exposed face in order to make a sharp, one meter-wide vertical column. The following are the artifacts which were screened from the debris. The first stratum encountered at the surface is the Aeolian which contained no artifacts. The 1982-83 El Niño sheet wash was also void of any remains. Directly beneath the 1982-83 deposits were the Chuza flood deposits from which only three colonial sherds were recovered. The Midden, directly below the Chuza deposits, was rife with 139 potsherds, all of which were Chiribaya, except for one possible Burro Flaco sherd. Besides the many potsherds, the midden also included many marine shells, unknown mammal bones, camelid bones, Cuy bones, fish vertebrae, and some unidentified bird bones. All of these remains probably represent refuse from eating. A few lithic flakes and 1 lithic point were also found in the

Table 6-22 Excavated Data from Pocoma Quebrada

Unit #1	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Camelid Bones	Cuy Bones	Bird Bones	Fish Bones	Cane
Level #1 0-10 cm.	Aeolian	0	0.0	Many								
Level #2 10-20 cm.	Miraflores	0	0.0	Few								
Level #3 20-30 cm.	Miraflores	0	0.0	None								
Level #4 30-40 cm.	Miraflores	0	0.0	None								
Level #5 40-50 cm.	Miraflores	0	0.0	None								
Level #6 50-60 cm.	Not Excavated	0	0.0	None								
Level #7 60-70 cm.	Not Excavated	0	0.0	None								D.R.S. 1995

Table 6-23: Excavated Data from Pocoma Quebrada

Geologic Column #1	Deposits are:	Sherds	Weight in Grams	Marine Shells	Lithic Flakes	Lithic Points	Unknown Mammal Bones	Camelid Bones	Cuy Bones	Bird Bones	Fish Bones	Cane
Natural Stratum Used	Aeolian	0	0.0									
Natural Stratum Used	1982-83 El Niño	0	0.0									
Natural Stratum Used	Chuza	3	37.30	None								
Natural Stratum Used	Midden	139	1,007.50	Many	Few	1	Yes	Yes	Yes	Yes	Yes	
Natural Stratum Used	Miraflores	0	0.0	0								
												D.R.S 1994

midden. Once again these lithic materials could be interpreted as an indication that the Post-Flood survivors had to engage in hunting and/or fishing activities. The Miraflores deposits contained nothing, but a piece of Classic Chiribaya pottery with a "Bowtie" motif was found at the contact point of the midden and the Miraflores deposits.

Table 6-24A and 24B lists the contents of Unit #2, which was located on a domestic terrace. This unit was without a doubt the most exciting unit of the field season since it contained irrefutable evidence of rebuilding by the Chiribaya after the Miraflores Flood because the flood deposits had been dug into to make a floor for a house. The Aeolian layer, L. #1, contained nothing. L. #2 was a composite layer of agricultural refuse and Miraflores deposits, which began at 19 cm below the surface. L. #2 contained 7 historic sherds and some marine shells. Other remains included some unidentified mammal bones and some gourd seeds. Only one lithic flake was found in this level, which leaves the impression that its presence might be an aberration, but more flakes were found deeper in the unit. L. #3 was also a composite layer with the upper portion consisting of Miraflores deposits, and the lower portion consisting of occupation debris from the floor of a cane structure. Fifty-six sherds, some marine shells, and 1 lithic flake were included in this level. Remains from a number of comestibles found in the unit included more gourds seeds, Guinea Pig bones, a few camelid bones, and fish vertebrae. Also braided human hair, S-spun alpaca thread, and some raw alpaca wool were recovered. Of

Table 6-24A: Excavated Data from Pocoma Quebrada

Unit #2	Deposits are:	Sherds	Weight in Grams	Marine Shell	Lithic Flakes	Lithic Cores	Gourd Seeds	Human Bones	Camelid Bones	Cuy Bones	Bird Bones	Fish Bones
Level #1 0-10 cm.	Aeolian	0	0									
Level #2 10-20 cm.	Agric./ Miraflores	7	95.60	Yes	1		Yes					
Level #3 20-30 cm.	Miraflores/ Midden	56	510.75	Yes	1		Yes		Few	Few		Yes
Level #4 30-40 cm.	Midden	44	330.80	Yes	2	1	Yes	1			1	
Level #5 40-50 cm.	Midden	24	270.00	Yes	1				1	Few	Few	Yes
Level #6 50-60 cm.	Miraflores	3	43.50	Yes								
Level #7 60-70 cm.	Not Excavated											D.R.S. 1993

Table 6-24B: Excavated Data from Pocoma Quebrada

Unit #2	Deposits are:	Sherds	Weight in Grams	Human Hair	Braided Human Hair	Alpaca Wool	Spun Alpaca Wool	Cane	Unknown Bone	Coprolite	Textile Frags
Level #1 0-10 cm.	Aeolian	0	0								
Level #2 10-20 cm.	Agric./ Miraflores	7	95.60						Yes		
Level #3 20-30 cm.	Miraflores/ Midden	56	510.75		Yes	Yes	S-Spun Thread	Yes			
Level #4 30-40 cm.	Midden	44	330.80	Yes					Yes	1	
Level #5 40-50 cm.	Midden	24	270.00						Yes		
Level #6 50-60 cm.	Miraflores	3	43.50						Yes		
Level #7 60-70 cm.	Not Excavated										D.R.S. 1993

course, there were many canes which were used for one wall of the structure. L. #4 was purely occupation debris with 44 Chiribaya sherds, marine shells, 1 coprolite of unknown origin, bird bones, and some unidentified mammal bones. Human remains included some hair and a pelvic bone. A small well-used lithic core and two lithic flakes were also found in L. #4. L. #5 consisted of more occupation midden yielding of 24 sherds, marine shells, and another lithic flake. Additional remains included 1 camelid bone, a few Guinea Pig bones, more fish vertebrae, several bird bones, and more identified mammal bones. L #6 was once again into pristine Miraflores deposits, and, therefore, contained scant remains, but, nonetheless, 4 Chiribaya sherds and some unidentified mammal bones were recovered.

Figure 6-1 is a cross section drawing of Unit #2, which helps explain the complicated stratigraphy of this unit. The upper 6 cm of this unit consist of aeolian fine sand and silt. Immediately beneath the 13 cm of agricultural refuse, the Miraflores deposits begin 19 cm on the east half of the unit and extend down to at least 70 cm below the surface, where my excavating stopped. The occupation midden, a 25 cm thick stratum in the west half of the unit, is found from 35 cm to 60 cm, where the Miraflores deposit are again encountered. Therefore, since the Miraflores deposits start at 19 cm, the survivors of the Miraflores Flood had to have excavated at least 41 cm in some places to make the level floor for their new dwelling.

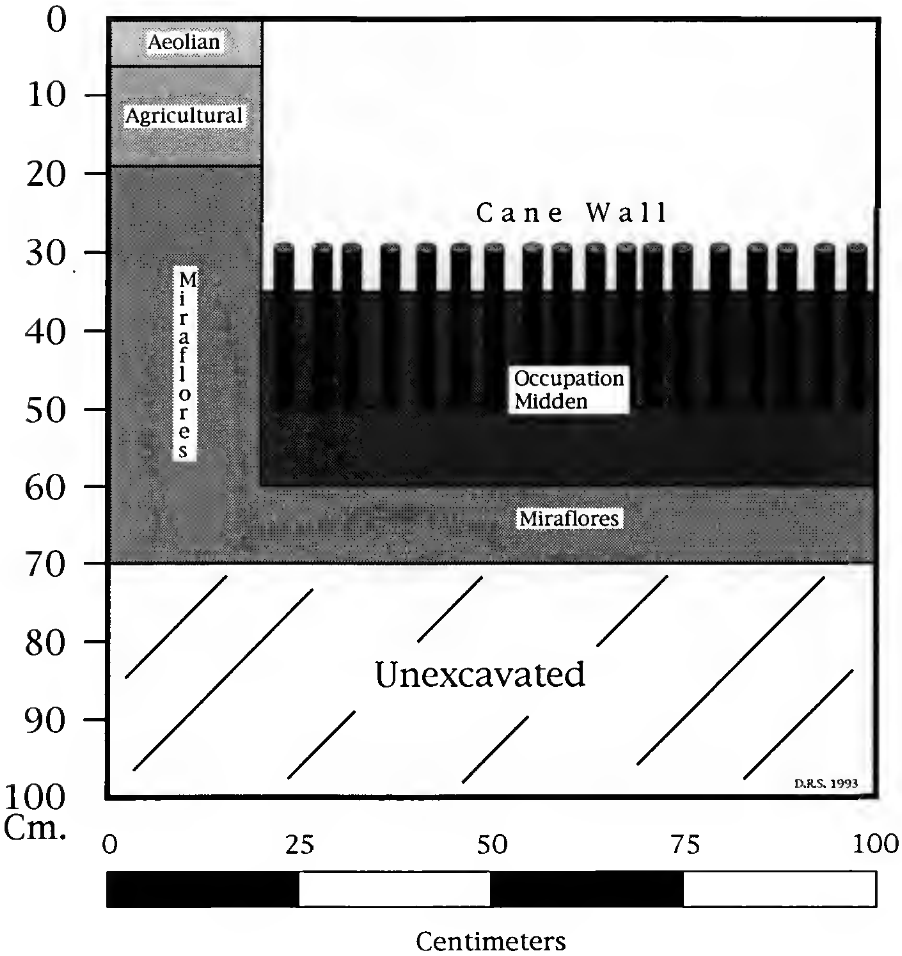
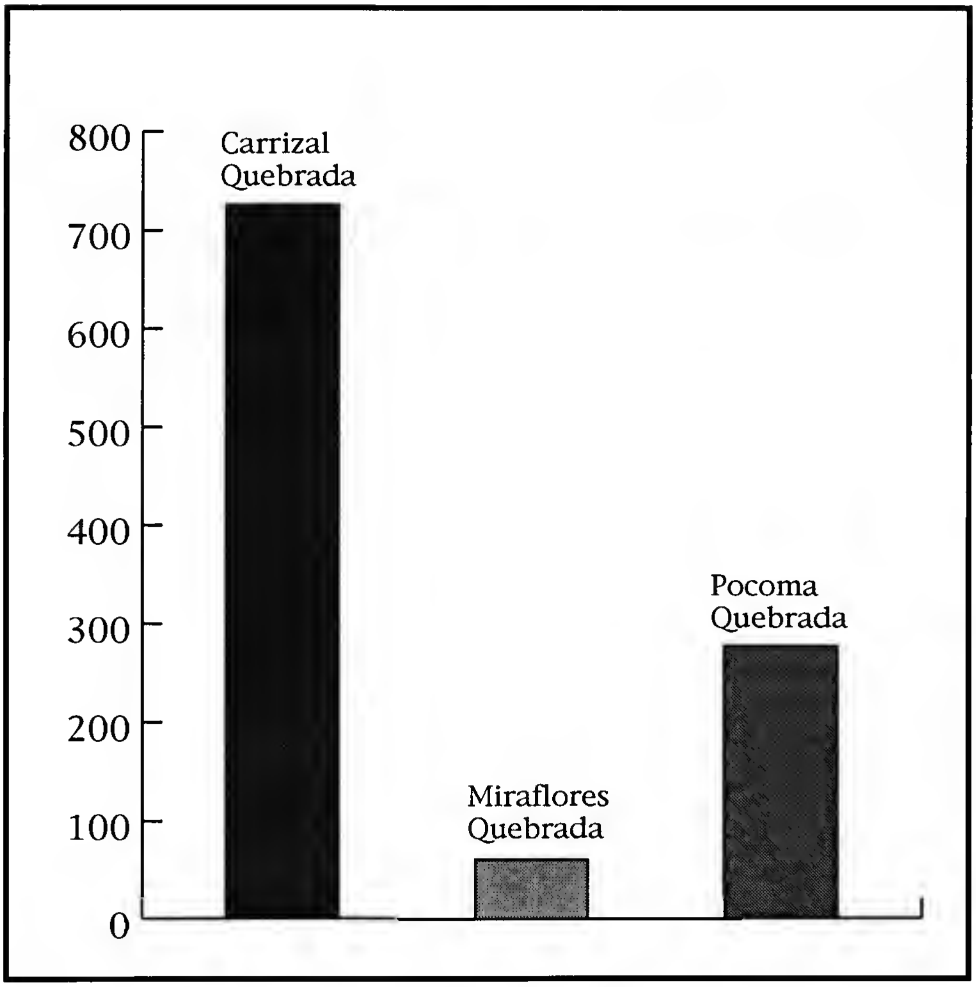


Figure 6-1: Cross-Section of Unit #2 at Pocoma Quebrada

Agricultural refuse had replaced the other 16 cm of excavated Miraflores flood debris overlying the midden, which explains how a colonial sherd could be included in L. #3, which, at first glance, appears to be a level that should have been entirely composed of the Miraflores deposits beginning at 19 cm below the surface. Further, the split stratigraphy of this unit accounts for the fact that there was some Huayna Putina ash found in the northwest corner of the unit in L. #3. Normally, it would be a physical impossibility for the 16th century A.D. H. P. ash to appear 10 cm below the level of the 14th century A.D. Miraflores deposits, but since the flood deposits had been excavated away in some places during the 14th century, it is possible to have H. P. ash in L. #3.

What Recovered Artifacts Indicate about the Strength of the Flood

The number of artifacts can be used to infer the seriousness of the two flood events, which impacted the study area. For example, Graph 6-1 shows the summary data of the sherd distribution for each quebrada. It is obvious that the excavations at Carrizal Quebrada produced more than two and a half times the number of sherds as did its closest competitor, the Pocoma Quebrada. Although Miraflores Quebrada probably had the largest native settlement and more units were excavated there than at the other two locations, nevertheless, the total number of sherds recovered from Miraflores Quebrada was only 60.

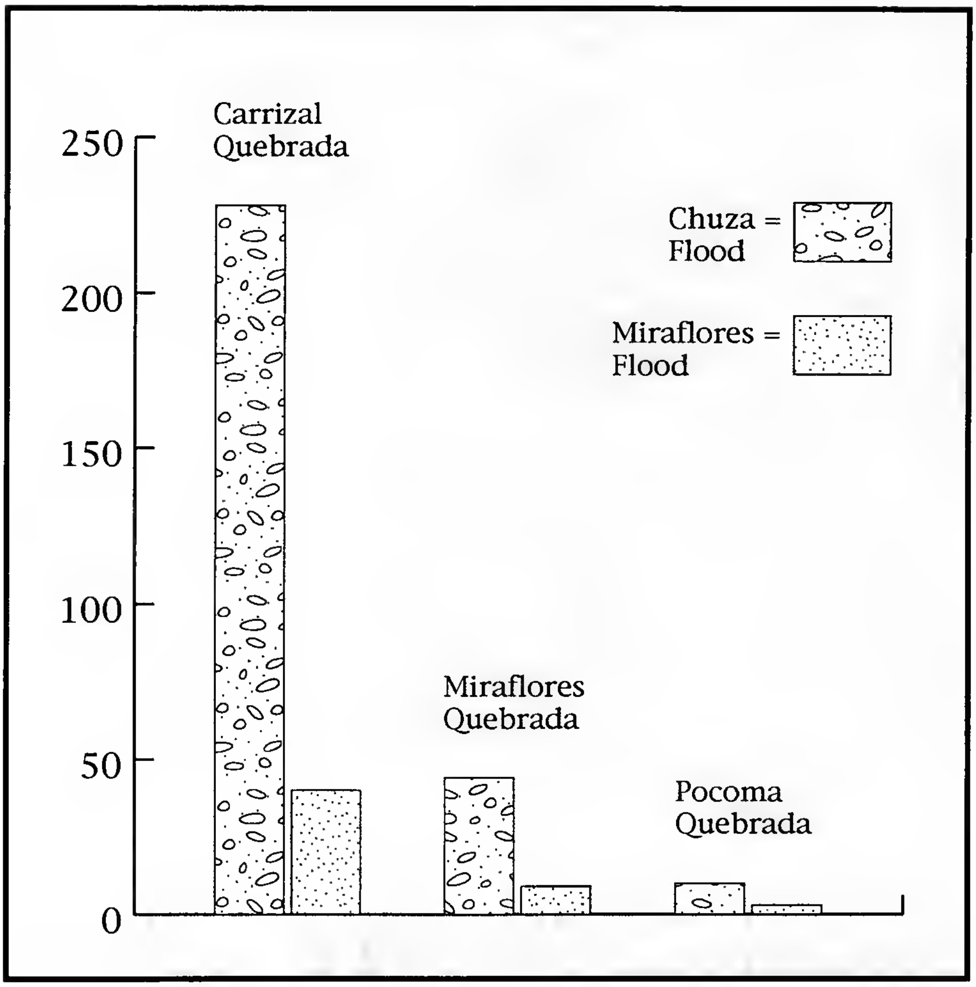


Graph 6-1: Sherd Distribution for all Units and Levels

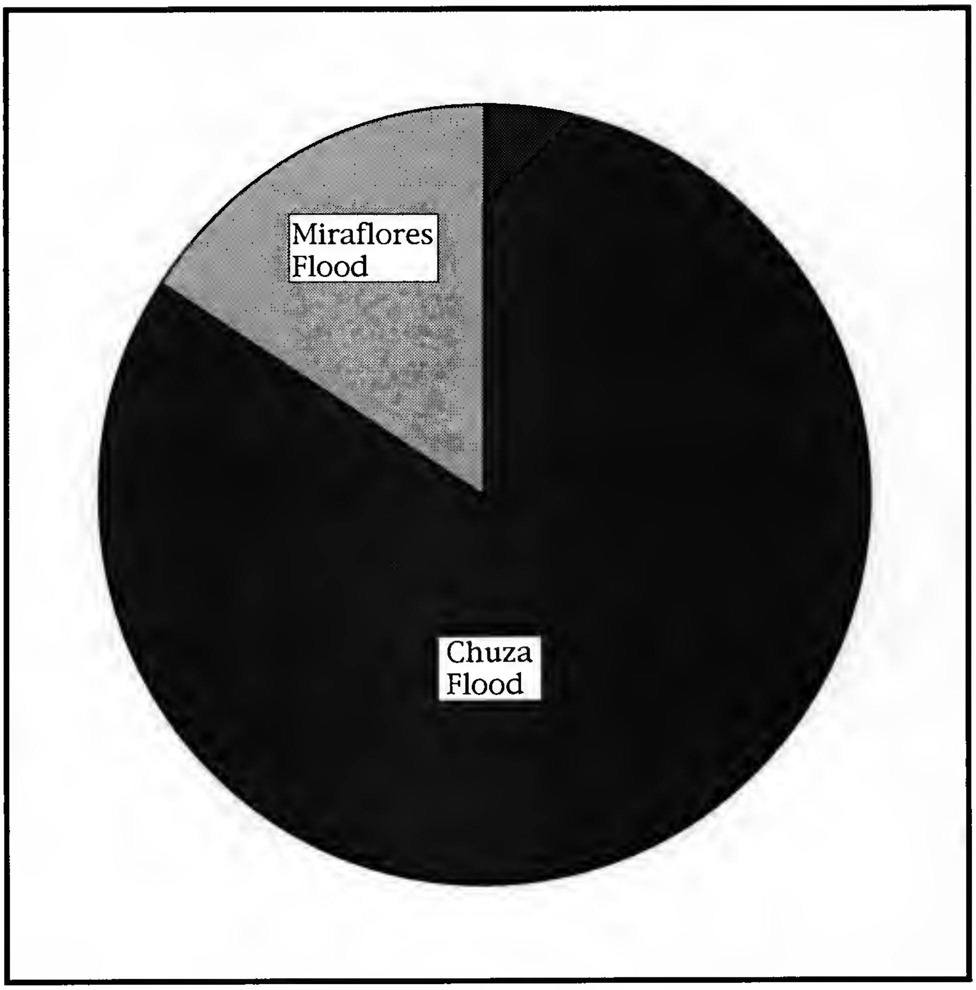
There can exist at least three possibilities for this large discrepancy in sherd distribution. The first possibility is that even though the settlement at Miraflores covered a rather large area (about 140 m by 140 m), the settlement had fewer residents than the other investigated locations. This is probably not the case, since many L.I.P. settlements were homogeneous sites which tended to have houses evenly spaced with an estimated five persons per household. Therefore, since the settlements at both the Carrizal and Pocoma Quebradas were smaller than the one at Miraflores, then the proposition that there were fewer people residing at the Miraflores Quebrada at the time of the flood seems to be negated.

Another possibility for this large discrepancy could be that, for whatever reason--civil upheaval, severe climatological change, tectonic uplift, mammoth earthquakes, or a volcanic eruption larger than Huayna Putina--some of the quebrada settlements were sparsely inhabited by the time the Miraflores Event occurred, and, therefore, the number of sherds available for potential recovery should be smaller. Even supposing that the Carrizal Quebrada was totally abandoned for some years by the time of the Miraflores Event, as proposed by Ortloff and Kolata (1993), the abandonment of the settlement could not sufficiently explain the abundance of sherds found at the Carrizal Quebrada and the paucity of sherds found at the Miraflores Quebrada. Based on the premise of settlement abandonment sometime prior to the Miraflores Flood, it seems that the distribution of sherds should be reversed for the two quebradas.

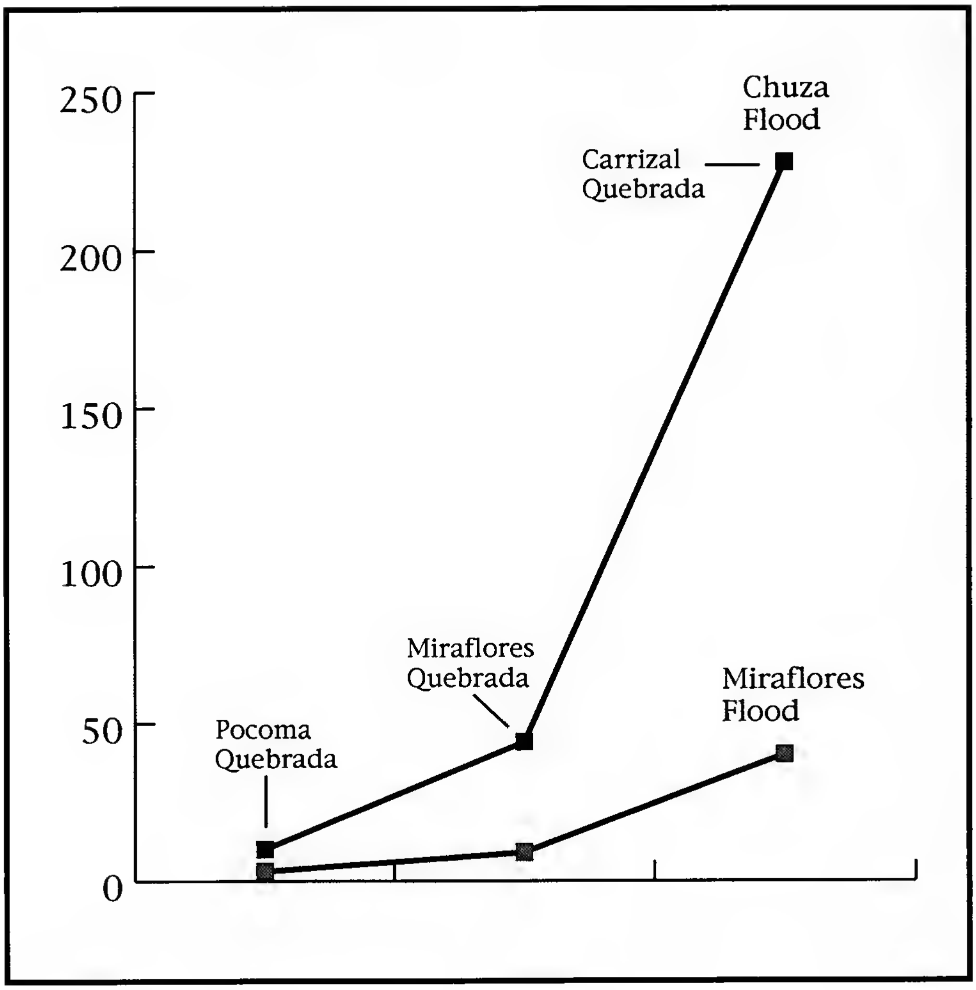
But the third possibility that the Miraflores Flood was simply so strong that it nearly obliterated all traces of the fairly large Chiribaya population in these quebradas seems to be the most likely possibility, based on all of the evidence gathered for this study. Graphs 6-2, 6-3, and 6-4 show the sherd distribution per flood event. The information presented unequivocally demonstrates that regardless of the quebrada or the number of units excavated, the number of sherds included in the Chuza Flood overwhelmingly outnumbers the number of sherds found in the Miraflores Flood by a minimum of 3.33 times at Pocoma to a maximum of 5.7 times at Carrizal. Even an analysis of the scant remains from the Miraflores Quebrada, where more units were dug than at the other two quebradas combined, illustrates that 4.89 times as many sherds were recovered from the Chuza Flood layers, as from the Miraflores Flood deposits. Graph 6-5 shows that the sherd weight distribution of the materials found in the Chuza Flood deposits are 6.81 times more than those included in the Miraflores sediments. The reason for this significant difference is the fact that based on the variance in the depths of the two floods at the coastal quebradas and in the Ilo Valley, the size of the Miraflores Flood exceeded the proportions of the Chuza Flood by a factor of several magnitudes. Therefore, it would be expected that the lesser event would not have swept away nearly as much of the cultural materials as the greater event would have done.



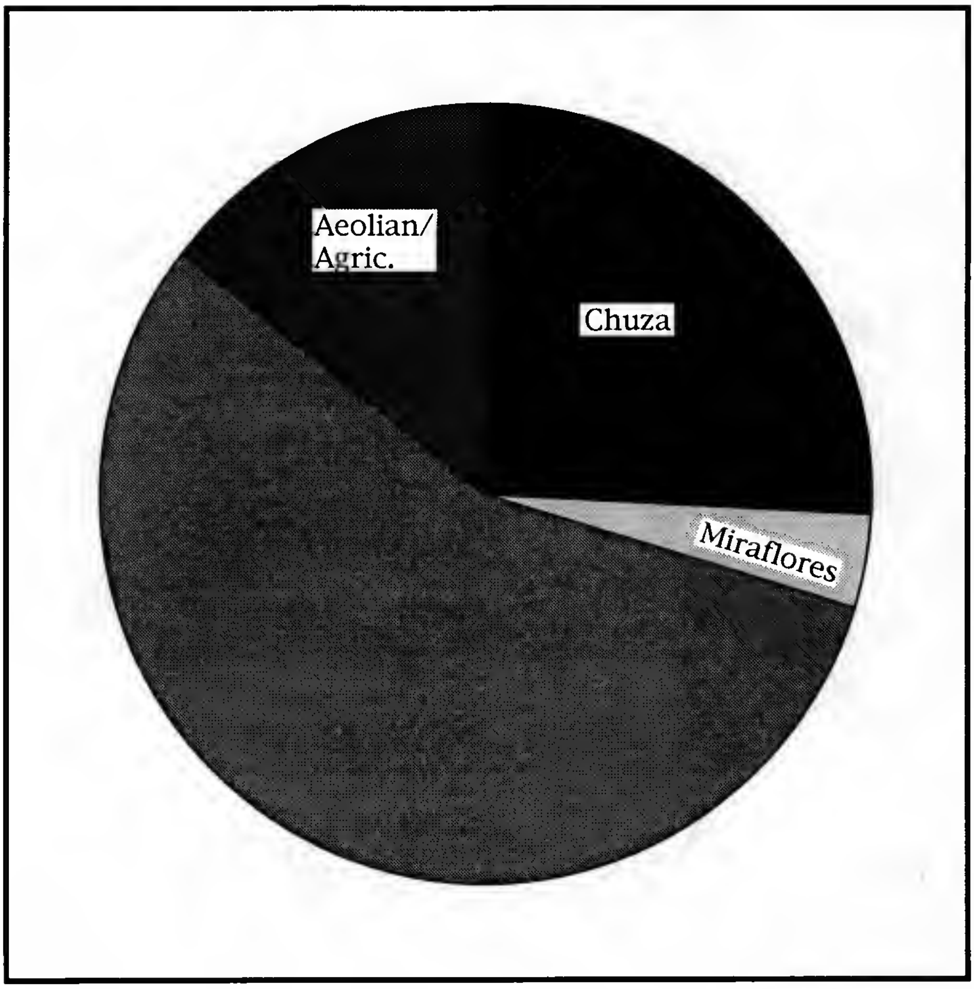
Graph 6-2: Sherd Distribution per Flood Event



Graph 6-3: Sherd Distribution per Flood Event



Graph 6-4: Sherd Distribution per Flood Event



Graph 6-5: Sherd Weight Distribution per Natural Strata

What Recovered Artifacts Indicate about a Cultural Response or Change caused by the Impact of the Miraflores Flood

The archaeological evidence found in the coastal quebradas and in the Ilo Valley indicate that the flood damage to the Chiribaya agricultural system was so extensive that the culture experienced a rapid, profound change (punctuated equilibrium--Eldredge 1989; Eldredge and Gould 1972; Gans 1987; Gould and Eldredge 1977). The evidence of widespread destruction indicates that, at the minimum, the direct effects of the flood caused: Many coastal and valley sites, long occupied by the Chiribaya, to be abandoned; At least one formerly abandoned site, San Geronimo, to be re-occupied; Agriculture to contract severely; The Chiribaya people to adopt a new subsistence base; and, based, tentatively, on the Burro Flaco pottery, to change their art and iconography.

There are a number of indicators of a potential rapid cultural change. Although the sample is small and the evidence is admittedly superficial, nonetheless, the fact that lithic materials, such as flakes, a few points, and a worked core, were found at every quebrada could be interpreted to mean that the Chiribaya people were again making and using lithic tools. The presence of lithic debitage by itself may not be adequate to argue conclusively for a change in the subsistence base; however, since we are already aware of the evidence from the Burro Flaco and the San Geronimo Sites, it seems quite logical to conclude that the Chiribaya were indeed again using lithic materials, some of which were employed as hunting points, such as the one found embedded in the proximal

end of a rib from a large sea mammal. The few points found during my excavations were much smaller, 2-3 cm, and are the type often used to hunt small mammals or birds.

Why were the Agricultural Terraces near Ilo Abandoned?

The most obvious and logical reason for the abandonment of the agricultural terraces in both the Ilo Valley and the coastal quebradas is the immediate damage done to them and to the canal systems by a major 14^{th} century A.D. El Niño flood as this study has shown. Nevertheless, most modern theorists seem to ignore these facts and, instead, espouse one of the two most popular theories for terrace abandonment are: 1) Depopulation or 2) Climatic Change. They seem oblivious to the more reasonable possibility that both of these factors could have played some part in terrace abandonment, but that an even more significant role was played by the almost total destruction of these terraces by a cataclysmic event such as a Mega-Niño followed by its resulting massive floods.

The depopulation theory holds that as the population decreases, the amount of available labor required for intensive projects would presumably be less. Therefore, the terraces farthest from the settlements would necessarily have to be abandoned. Since "terraces must constantly be maintained lest they degenerate in response to environmental hazards such as erosion, landslides, mudslides, and flashfloods," (Guillet 1987c:193), with a decrease in population, there simply would not be enough people to fulfill the large labor requirements needed to maintain and clean irrigation canals or to fertilize and seed the planting surfaces. Archaeological

evidence from the Ilo region supports the idea that there was a decline in population following the disastrous 14th century El Niño flood based on the fact that late in the Chiribaya Period, settlement size in the Ilo area did decrease (Owen 1991 and 1992a.). However, standing in opposition to this declining population theory is the fact that the terraces at Otora, about 100 km from Ilo, were abandoned in a context of demographic growth and agricultural intensification (Stanish 1987:340).

It is almost a certainty that the population declined after the Miraflores Flood. Drawing on modern health data, it is easy to see that there will be various epidemics, such as malaria, leishmaniasis, cholera, and others, in the weeks and months after an El Niño. Lacking modern medicine, prehistoric populations must have been even more severely affected than modern populations. It has been proposed that local Chiribaya population had declined by 80% or more by 1400 A.D. (Owen 1991). Nevertheless, it was probably not the lack of adequate labor to repair or to rebuild the agricultural system which caused the abandonment of the terraces, but rather the fact that there was not even a repairable, semi-functioning irrigation system left, following the Miraflores Flood.

Climate change is the second of the standard theories used to explain the abandonment of agricultural terraces. Currently, there is much confusion concerning the character of the Andean Paleoclimate. Based on glacial ice core data, the climate may have changed to a drier regime with below average precipitation from 1200-1500 A.D. (Thompson et al. 1985), and a severe drought may have occurred between 1245-1310 A.D. (Thompson et al 1983).

Ortloff and Kolata (1993) also posit that a shrinking water supply characterized the years from 1100-1300 A.D., with a marked decline beginning in 1350 A.D. or at least by 1400 A.D.

Were there a severe, prolonged drought earlier than 1300 A.D., the Miraflores Flood probably would have obliterated any trace of its existence. The only archaeological evidence which was found that could support the idea of a harsh drought after 1400 A.D. is the fact that there are substantial strata (90-120 cm) of aeolian deposits, separating the two flood events at the Carrizal and Chuza Quebradas, respectively. However, there are no such deep aeolian deposits found anywhere at the Miraflores Quebrada. Thus, proof is still lacking and the question remains open.

Contrary to these claims for the drier centuries from 1000-1400 A.D., Conrad (1981) maintains that this time was a wet period, with the drier conditions starting after 1400 A.D., which lead to the loss of marginal agricultural land. Paulsen (1977) states that there was a humid climate that endured from 100-1400 A.D., with drier periods lasting from 600-1000 A.D., and again after 1400 A.D. Based on the studies of calcite buildup in the Lauricocha cave, Cardich (1964) also states that the period from 1000-1400 A.D. was wet and cold. Analysis of ice core data from the glacial fields of Greenland indicates that the world climate from 1200 A.D. until the mid 1850s A.D. was colder (and probably wetter) than it has been since the last glaciation (Matthews 1987). Ice core data from the Quelccaya Glacier record the period from 1500-1720 A.D. as the wettest in the last thousand years (Thompson et al. 1986). While yet another source reports that the climate has become increasingly

warmer since about 1500 A. D. (Richardson 1978). There is probably no method to recover evidence, which could support the idea that 1000-1400 A.D. was a wetter period, other than analysis of micro-stratigraphy left by the undoubtedly thinner moist aeolian strata. So, the controversy rages on concerning whether the climate in these time periods was wet or dry--cold or warm.

If there truly were a paucity of moisture, it could have caused some contraction of the total agricultural area for the Chiribaya Culture before the occurrence of the massive El Niño inundation. Unlike the Chimu on the north coast, who built a 74 km-long Intervalley Canal that brought additional water to the Moche Valley to offset the gradual decrease in their water supply (Ortloff 1994), the Chiribaya apparently had no other available water supply to aid them during such a drier period. Below average rainfall also could have affected the spring flows such as has been demonstrated for the last 400 years in the Carrizal Quebrada (Clement and Moseley 1991). Since there is conflicting evidence, and in some cases none at all, concerning the exact nature of the Paleoclimate from 1000-1400 A.D., only more intensive research concerning climatological data may eventually be able to answer definitively the question of whether this period was truly drier or wetter.

Still other less widely known possibilities for the abandonment of terraces include the initial water loss of as much as 50% in earth-banked canals from seepage and evaporation, which could possibly lead to the reduction of the total downslope irrigated area. This idea has been posited for the upper Moquegua Drainage. In spite of this claim, valley bottom canals are the most efficient

with regards to seepage loss and evaporation. Thus, they were used as an agricultural strategy throughout the Late Horizon and into modern times (Stanish 1987:357-360).

Tectonic uplift has also been mentioned as a possible cause of terrace abandonment in some areas of Peru. Uplift of the landscape changes the junction and slope of irrigation canals, causing an uphill slope of canal beds (Kus 1972; Moseley et al. 1981; Moseley 1983a; Moseley and Feldman 1984; Ortloff 1988; Stanish 1992), and can eventually cause the downcutting of water sources and the stranding of canal intakes (Clement and Moseley 1991). Some authors maintain that uplift affecting canal slopes has yet to be demonstrated anywhere in Peru since the canals should show evidence of stretching and warping from uplift (Denevan 1987; Farrington 1985). However, evidence of tectonic canal distortion is documented by the Peruvian agencies which surveyed the disputed canal system. The older sections of the canal system run uphill, while the newer sections now have a zero slope. A 1° to 2° slope change in also recorded during the Chimu phase (900-1200 A.D.) at Chotuna on the north coast (Donnan and Ortloff 1982). There is little doubt that uplift is a continuous process along the Peruvian coast, because plate convergence causes 1 to 2 cm vertical movement per year in many areas of Peru (Ortloff et al. 1983:377), and since the Chimu canals typically had a slope of less than one-half a degree (Ortloff 1994), even a minute amount of vertical displacement could adversely affect the water flow.

However, unlike the north and central coasts of Peru which are plagued by major tectonic activity, which can contribute to the

abrupt uplift of land masses, the study area is not often affected by large magnitude earthquakes. Although there have been a few significant events in the past, which affected the study area, (Silgado 1978), at present, there is little or no archaeological evidence demonstrating canal slope alteration. Therefore, even this possibility cannot be shown to have directly impacted the irrigation systems around Ilo.

In light of these conflicting theories for the abandonment of terraced agricultural systems and the contradictory evidence concerning the climatological status of the period from 1000-1400 A.D., analysis of the recovered data cannot support any single abandonment theory, but the substantial aeolian deposits included in some of the geologic columns do lend credence to the possibility of a drier period after the Miraflores Event, and thus, at least some progress has been made in distinguishing the probable from the improbable.

CHAPTER 7
PROFILE AND COLUMN DATA

Introduction

The purpose of this chapter is to describe in detail some of the unit and canal profiles and the geologic columns containing deposits from the Chuza and Miraflores Floods and to analyze these drawings in an effort to answer the following research questions: 1) What do the profiles indicate concerning the composition of the these two floods?; 2) Is the flood record and the stratigraphy consistent from quebrada to quebrada?; and 3) Were the same flood deposits found uniformly at all quebradas and at the various locations at each quebrada?

Carrizal Quebrada

Unit Profiles

Figure 7-1 shows the details of the profile of Unit #1 S. Excavation revealed that there were two aeolian layers. The aeolian deposits near the surface were composed of 6 cm of dark brown (10YR 4/3) sand with some silt, which overlies a second layer of grayish brown (10YR 5/2) aeolian sand and silt which extend to the bottom of the colonial irrigation canal, that has a 1 cm sediment layer in its bottom. It was observed that this canal is not stone-lined like

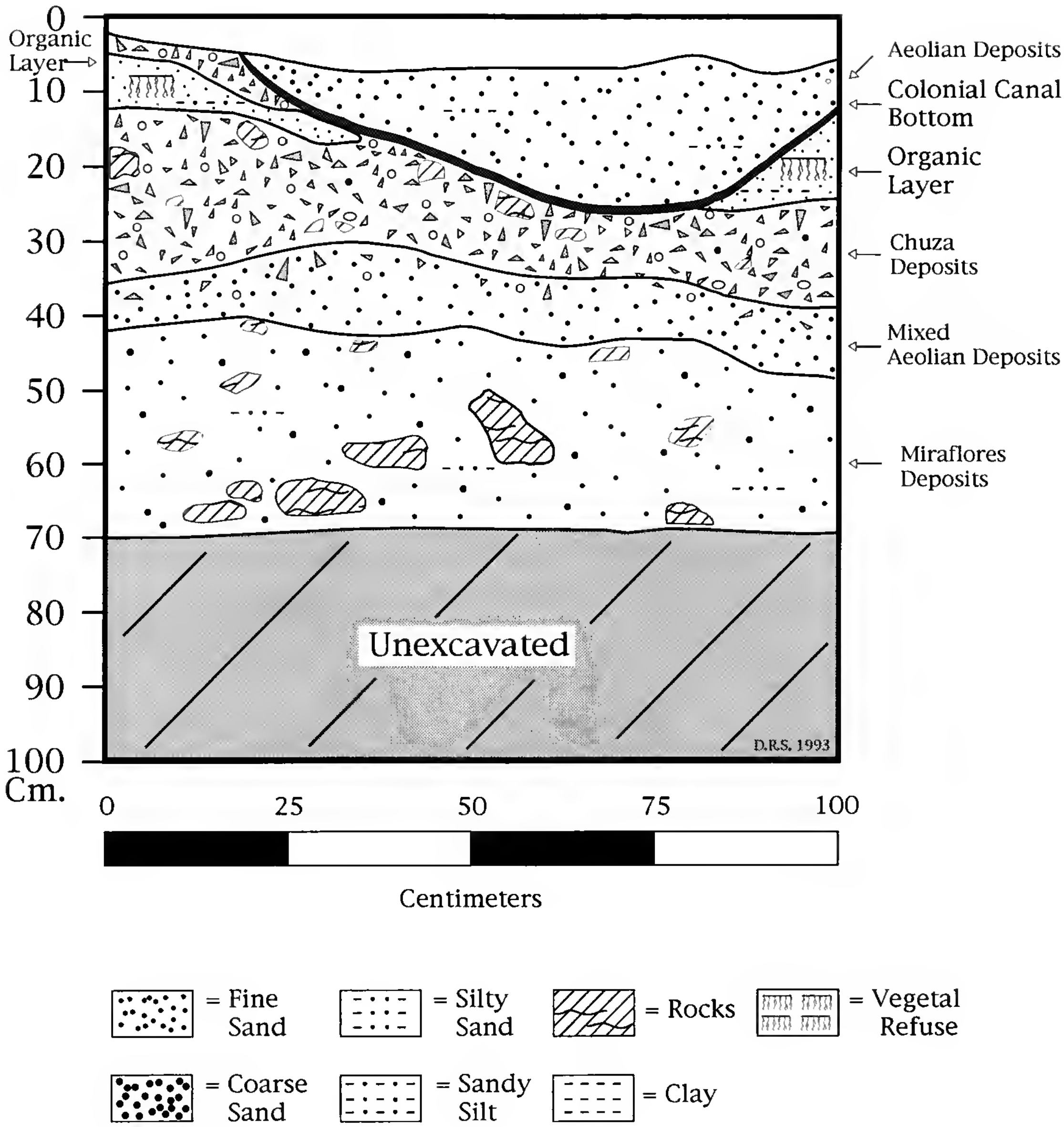


Figure 7-1: Unit #1S.--Carrizal Quebrada

those canals that are located ca. 220 m ESE along the base of the high domestic terraces (Figure 7-2A). Beneath the outside edges of the canal are what remains of a contiguous dark yellowish brown (10YR 4/4) organic layer which was excavated to make a canal bottom. This organic layer is composed of many small seashell fragments, 1 mm pebbles, fine sand, silt, and vegetal fibers. Since the irrigation canal lies adjacent to a prehistoric domestic terrace, it appears as if the organic materials are from this abandoned terrace. The 15-20 cm depth of the dark grayish brown (10YR 4/2) Chuza flood deposits contained small shell fragments, rock fragments, larger rocks up to 5 cm, sand, silt, and some vegetal fibers, which could have come from the former prehistoric domestic terrace that subsequently had been used as an historical agricultural surface.

Underlying the Chuza deposits is yet another yellowish brown (10YR 5/4) slightly mixed aeolian layer composed of fine sands and some 3 mm grit. This second aeolian layer overlies at least 25 cm of reddish yellow (7.5YR 6/6) Miraflores deposits which contain large rocks up to 20 cm, hundreds of smaller rocks, rock fragments, and sand with a small amount of silt, which could have been carried downslope from the upper agricultural terraces.

The depth of the flood deposits in U. #1 S. seems to indicate that the impact from Chuza was less here than at U. #4 S. (Figure 7-4), where the deposits from the Chuza Flood were 35 cm thick. The reason for the difference in the depth of the flood deposits must be that the Chuza Flood flow was split into two parts by the irregular terrain. At the area just below the olive grove, part of the mudflow overflowed the quebrada and rushed down between the domestic

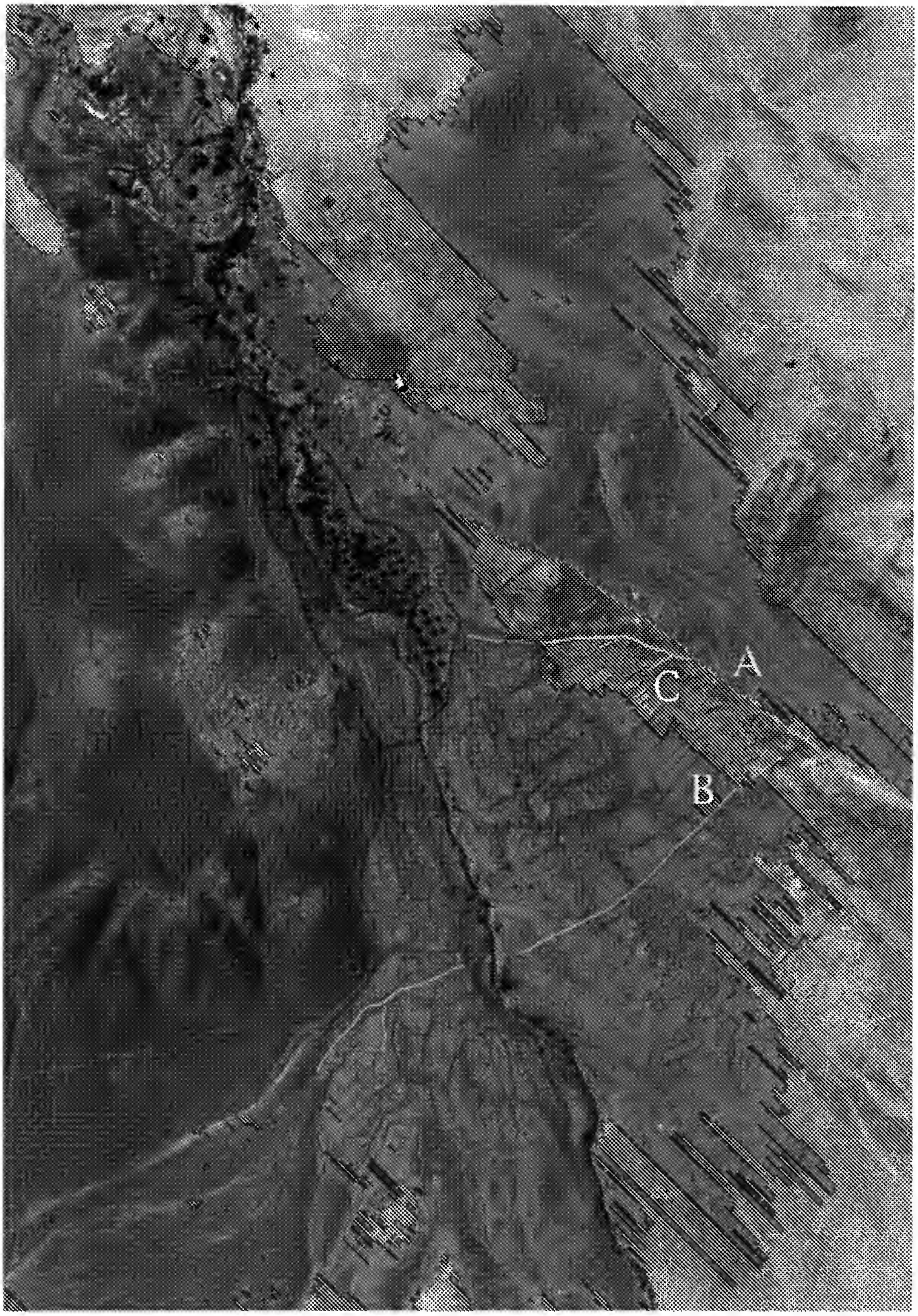


Figure 7-2: Aerial View of Carrizal Quebrada

terraces (Figure 7-2B), which accounts for the deeper deposits found in U. #4 S. The remainder of the flood surge continued down the main quebrada channel indicated at Figure 7-2C, and it is possible that the overbank deposits are the thinner sediments present in U. #1 S.

Figure 7-3 is the profile of Trench #1 South, which is a 40 cm wide probe cut into the canal in an attempt to find the canal bottom and to determine the depth of the flood sediments that were deposited closer to the quebrada channel. The 6 cm of dark brown (10YR 4/3) aeolian sand and silt caps a 1-2 cm stratum of "puddled" sand and some silt from the 1982-83 El Niño. Beneath the 1982-83 sediments are 16 cm of more dark brown (10YR 4/3) aeolian deposits which cover a 4 cm layer of grayish brown (10YR 5/2) mud and fine silt which rests in the bottom of the colonial canal. It is highly improbable that these sediments were the result of additional "puddling" from the 1982-83 event because of the thick 16 cm layer of wind blown sand and silt separating the canal bottom and the 1982-83 sediments. Further evidence indicating that this canal bottom is historic is the fact that dark grey (10YR 4/1) Chiribaya cultural debris was found directly below the canal bottom.

Figure 7-4 shows the profile of Unit #4 S. which is situated near the south edge of the domestic terrace. The 16 cm of brown (10YR 4/3) aeolian sand with very little silt overlie the very thick 40 cm of dark grayish brown (10YR 4/2) Chuza deposits consisting of hundreds of small rocks and rock fragments and fine sand with much

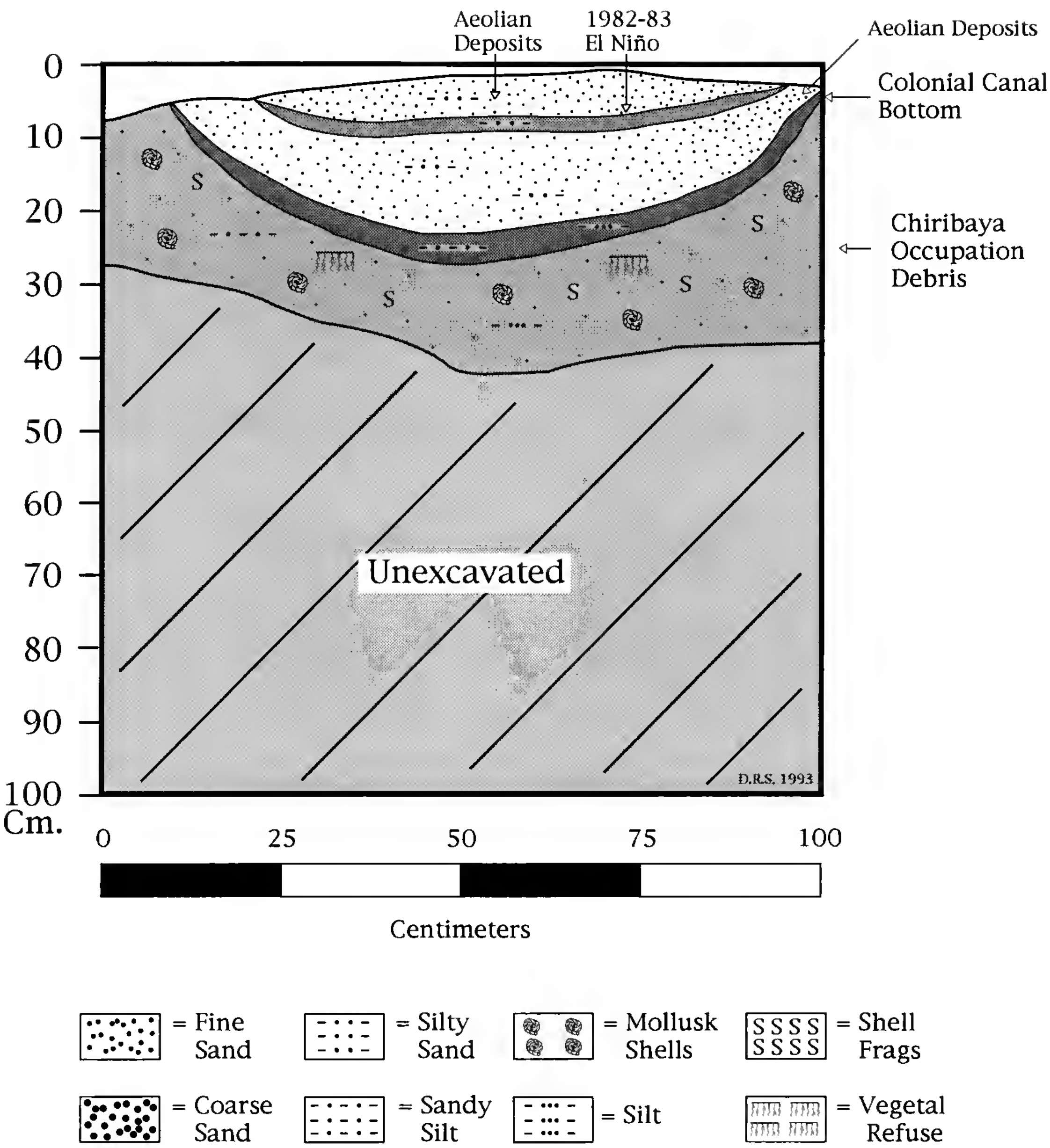


Figure 7-3: Trench #1S.--Carrizal Quebrada

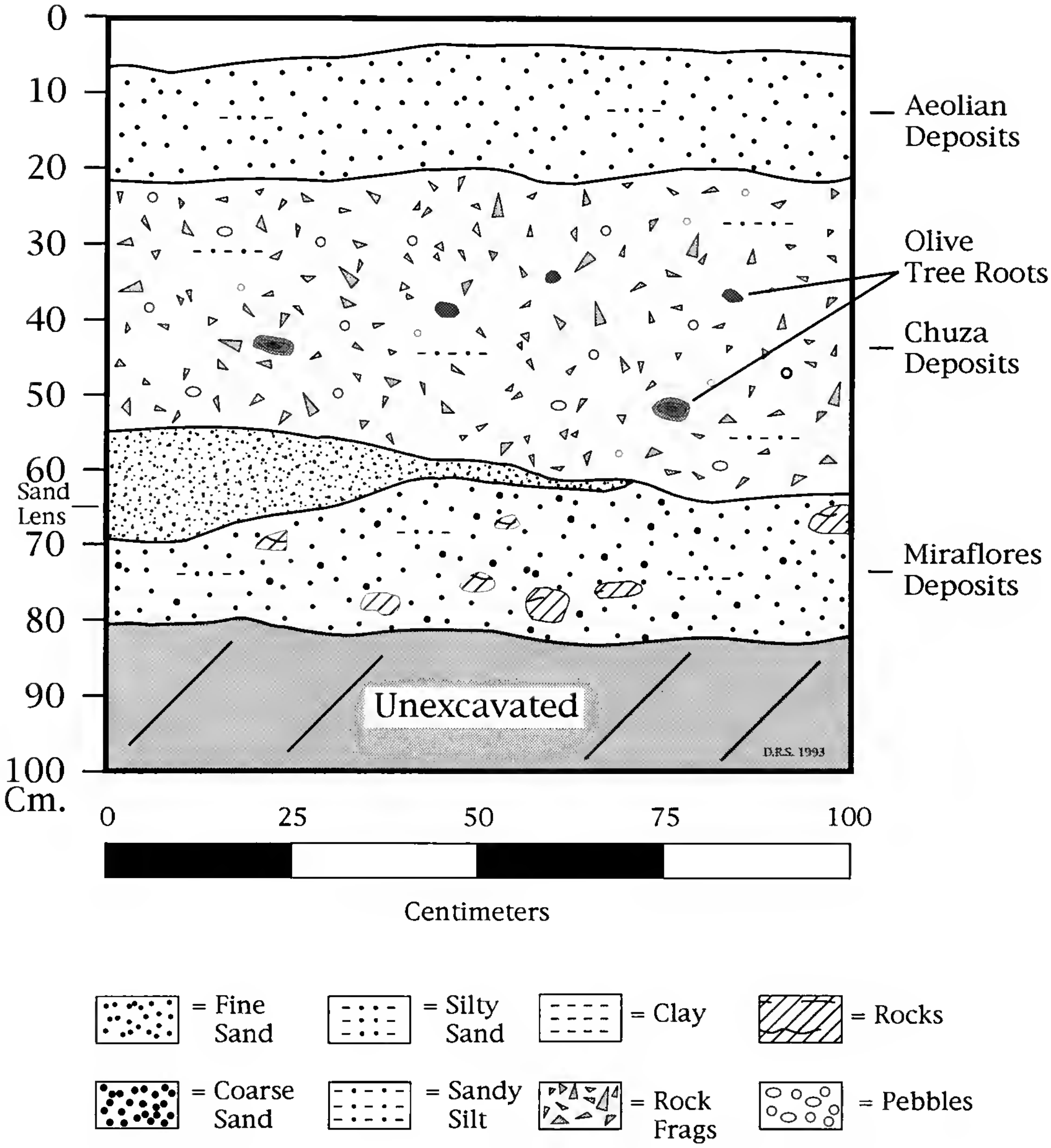


Figure 7-4: East Wall of Unit #4 S.--Carrizal Quebrada

more silt than found in Unit #1 S. The Chuza deposits are much thicker here than these same flood deposits found at the Miraflores Quebrada (20 cm). Partially separating the Chuza deposits and the Miraflores deposits is an unusual yellowish brown (10YR 5/6) aeolian root-laden, sand lens, which was somewhat consolidated where it contacted the very wet, reddish yellow (7.5 YR 6/6) Miraflores deposits. The 20+ cm thick Miraflores Flood sediments consists of sand, silt, and rock fragments, with some rocks up to 12 cm in size. The Miraflores deposits here include more small gravels in their lowest levels and are also a different color than the more characteristic pink or pinkish grey (7.5YR 7/4;7/2) deposits found in the Ilo Valley. However, in the river banks of the Ilo Valley, we were usually analyzing flood deposits which were the direct result of the outpouring of flood detritus from the neighboring quebradas.

Quebrada Geologic Columns

Figure 7-5 shows the rather interesting Geologic Column #1 located on the north side of the main quebrada channel. The uppermost stratum is the dark brown (10YR 4/4) 1982-82 El Niño deposits which included very sandy silt with some 2-3 mm pebbles. Immediately below these deposits are found the 43 cm thick yellowish brown (10YR 5/4) Chuza sediments with copious amounts of silty sand, rock fragments, and rocks up to 20 cm. Directly below Chuza is 1-2 cm of what appeared, at first inspection, to be salt-impregnated carbon. However, I now wonder if this may be a layer of Huayna Putina volcanic ash mixed with the carbon that is sometimes found in association with this ash. Beneath this mixed

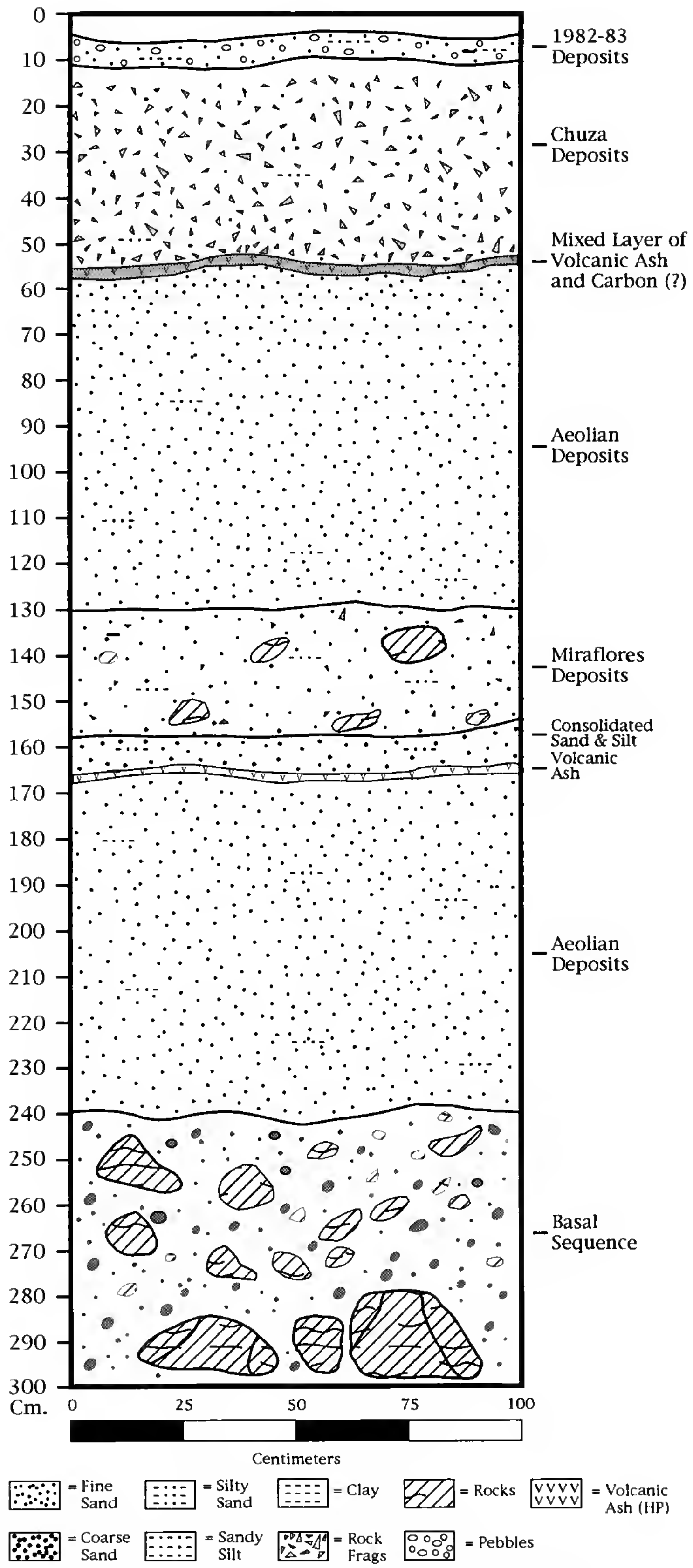


Figure 7-5 Geologic Column #1--Carrizal Quebrada

layer are the 70+ cm of brown (10YR 5/3) aeolian sand and silt which rest upon the more characteristic 34 cm deep, compacted pinkish grey (7.5YR 6/2) Miraflores deposits consisting of sand, silt, mixed rock fragments and large rocks up to 13 cm in length. Beneath the Miraflores sediments is what appears to be a thin 2 cm pinkish white (10YR 8/2) layer of volcanic tephra from a heretofore undiscovered volcanic eruption. If there were volcanic activity prior to the Miraflores Event, the concomitant earthquakes and tremors would have supplied more than ample materials for flood transport, which would account for the deep Miraflores deposits found in many locations. Beneath the volcanic ash are the 70-cm thick brown (10YR 5/3) sandy deposits of another aeolian layer. The rest of the 300 cm geologic column is filled by the Basal Sequence, which is difficult to analyze with the Munsell Color Chart because the Basal Sequence is predominantly made up of marine gravels and many very large rocks varying from 10-40 cm in diameter. The very bottom of the quebrada channel has a thin 1 cm mud veneer from the 1982-83 El Niño which encapsulates the Basal Sequence to a height of 1.5 m.

Miraflores Quebrada

Unit Profiles

Figure 7-6 shows Unit #1 N., which was located a few meters North of sunken feature #2. The profile reveals 3 distinct strata at this location. The uppermost stratum is composed of dark yellowish brown (10YR 4/6) aeolian fine sands and some silt averaging about 8 cm in depth. Immediately beneath the aeolian layer are the 20 cm strong brown (7.5YR 4/6) Chuza flood deposits consisting of

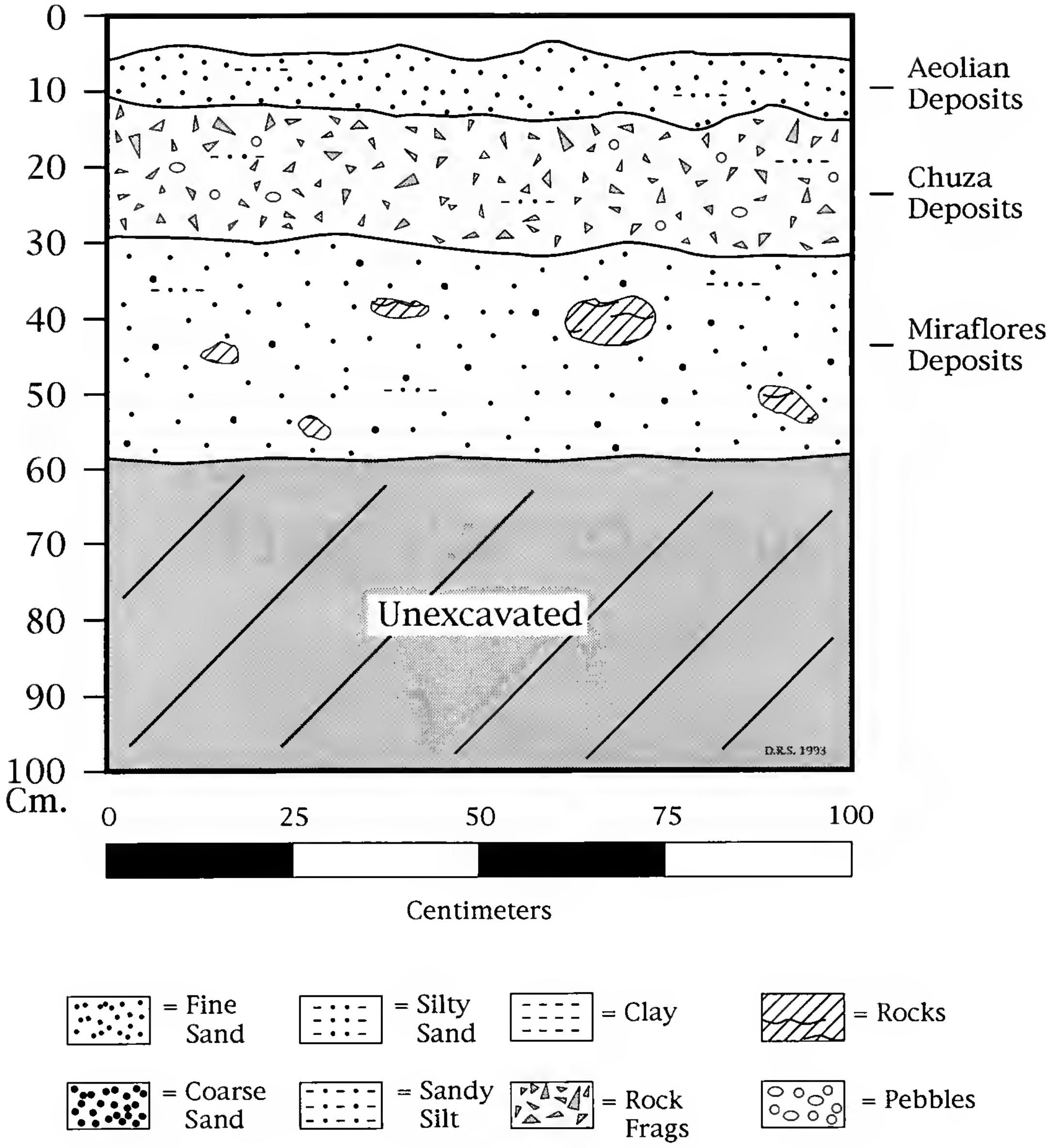


Figure 7-6: East Wall of Unit #1 N.--Miraflores Quebrada

consolidated coarse sand, some silt, grit, and hundreds of angular granitic rock fragments. The 30+ cm deep, dark brown (7.5YR 4/4) Miraflores sediments composed of very fine sand, silts, and large rock up to 10 cm in size, lie directly underneath the Chuza deposits. There is a variation in the color of both flood deposits at this location because darker silts from the occupation and agricultural terraces are incorporated into the flood residues.

Figure 7-7 is the profile drawing of Unit #3 N. Although Unit #3 N. is located only 10 m from Unit #1, the 8-10 cm of strong brown (7.5Y 5/6) aeolian sand and silt is a different color at this location. A possible explanation for this difference may be the fact that Unit #1 is located near the off-road route sometimes used by motor vehicles, and, consequently, the deeper deposits are mixed with the aeolian deposits. Even the 20 cm of strong brown (7.5YR 4/6) Chuza deposits show a different color than do these same deposits in the geological column located upvalley (see below). The stratigraphy of Unit #3 N. is identical to Unit #1 N. with the Chuza deposits located directly above the Miraflores deposits, which are uncharacteristically brown (7.5YR 5/4) sediments which are composed of sand, silt, small pebbles, larger rocks up to 15 cm, and one 60+ cm by 40 cm boulder. The boulder is at least 32 cm high, and it was buried by 38 cm of compacted Miraflores deposits. Figure 7-8 is the floor plan of Unit #3 N. showing the location of the large boulder, which was first thought to be a cap stone for an undisturbed Chiribaya tomb, of which there are several on the plain at the Miraflores Quebrada.

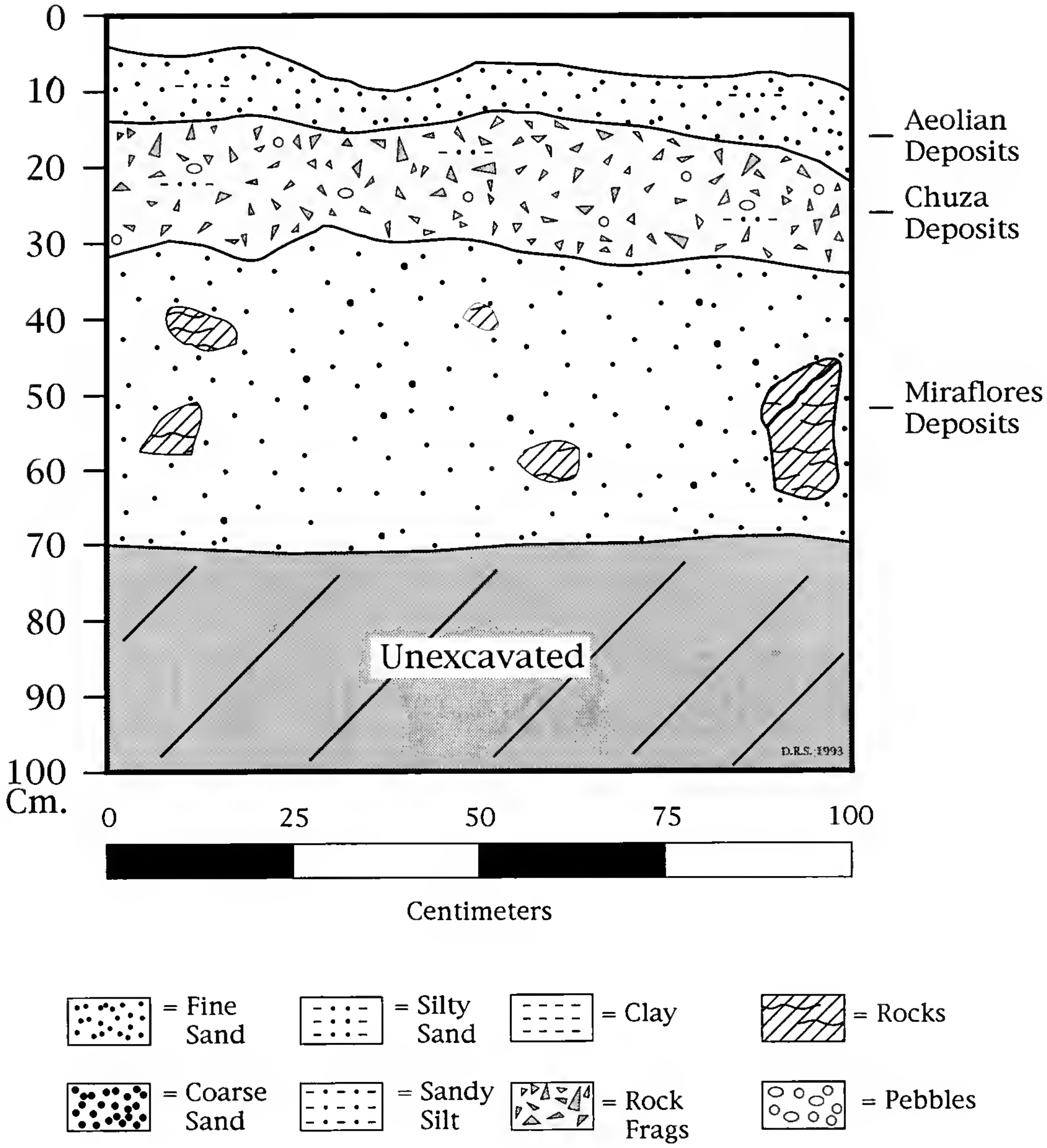


Figure 7-7: East Wall of Unit #3 N.--Miraflores Quebrada

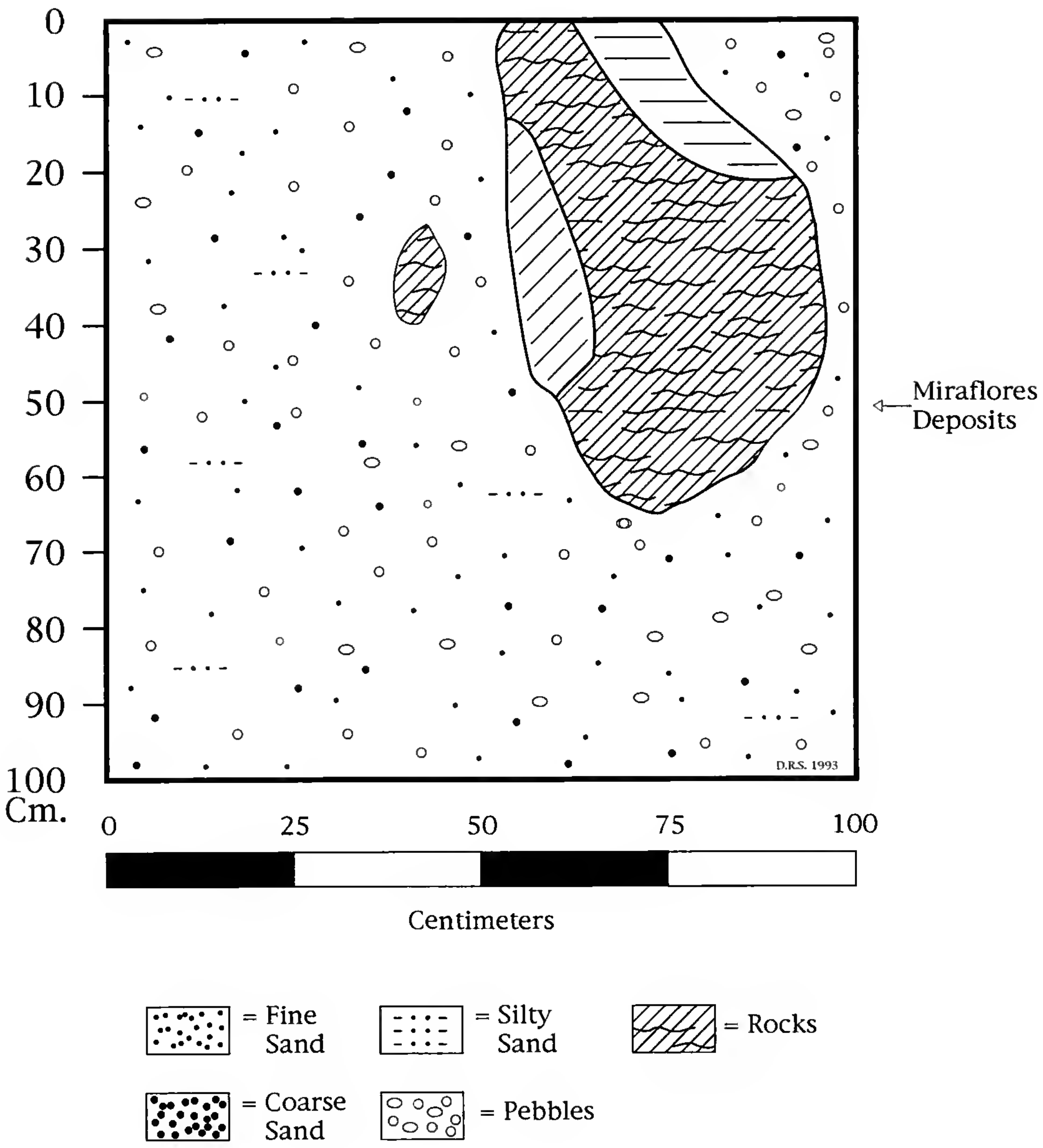


Figure 7-8: Floor Plan of Unit #3 at Miraflores Quebrada

Figure 7-9 shows the east wall of the Large Unit #1 excavated into the northern sunken feature, Pit #1. The 8 cm dark yellowish brown (10YR 4/6) aeolian layer, containing mostly silt, a little sand, and a small amount of clay, is basically the same as the other aeolian deposits thus far found at the Miraflores Quebrada. Since Pit #1 is located only a couple meters from the main quebrada, some of the 1982-83 El Niño overbank deposits are present in the profile. Four to five cm of its strong brown (7.5YR 4/6) sandy silt with a few small pebbles (4 mm or less) and some small rocks (1 cm or less) lie immediately beneath the aeolian stratum.

Capped by the recent El Niño mud are almost 40 cm of dark brown (7.5YR 4/4) Chuza flood deposits which are much thicker here than in any of the other 7 units excavated between here and the southern sunken feature, Pit #2. The reason that the Chuza deposits are more substantial here is because when the flood surge breached the east wall of Pit #1, the two meter depth of the pit accommodated more flood materials, independent of the speed of the torrent, leaving deeper sediments than the 20 cm average depth. Lying contiguously to the Chuza debris are the 50+ cm deep strong brown (7.5YR 5/6) Miraflores sediments, the constituents of which are sandy silt with a little clay, small rock fragments, and larger rocks up to 30 cm in length. Based on the 1990 excavations of a 1 m trench extending from the south wall of Pit #1 to the edge of the quebrada, the Miraflores deposits extend to 120 cm below the Chuza deposits at this location.

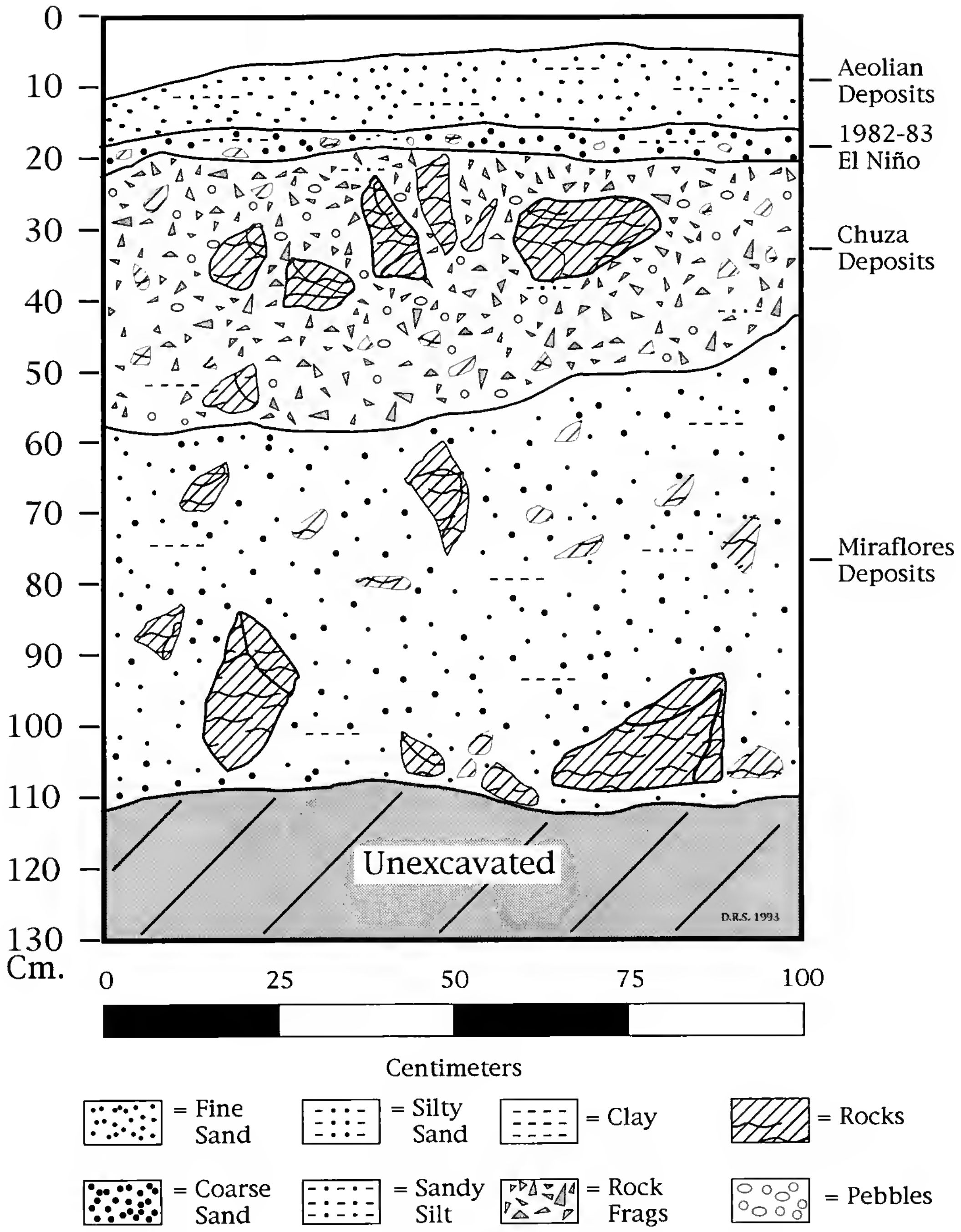


Figure 7-9: East Wall of Large Unit #1--Miraflores

Figure 7-10 is a drawing of the north view of the Large Unit #1. Since this profile shows a more involved stratigraphy than did the east view, the north profile provides an even better explanation of the total picture of what has geoarchaeologically transpired in the last five centuries since the Chiribaya Culture ceased to exist. The yellowish brown (10YR 4/6) aeolian deposits were the same thickness as in Figure 7-8, but they are not shown in Figure 7-9 since they had been previously removed in order to examine the carbon layer more closely (2 cm deep by 40 cm long by 9 cm wide), which was included in the very top of the Chuza deposits. This carbon layer was not caused by such high heat as the similar carbon layers found in two of the seven excavated units. The residue was not the result of burning agricultural debris, or the result of a cooking fire. Therefore, the origin of this carbon layer will have to remain a mystery until further excavations can be conducted at this site.

Figure 7-10 establishes that the dark brown (7.5YR 4/4) Chuza deposits vary from 12 cm to 20 cm in thickness at this location. There was a pronounced swag of about 20 cm in depth, located equidistant between the southeast and northeast corners of Pit #1, which accounts for the difference in the depth of the Chuza deposits in this profile and those shown in Figure 7-8. The swag may have originated from the 1990 field season when the trench was excavated. An exciting find in this profile is the presence of 4 cm of undisturbed Grayish white (10YR 8/2) Huayna Putina ash, which covers the strong brown (7.5YR 5/6) Miraflores deposits. At the base of the wall, in the southeast corner of this unit, some volcanic ash

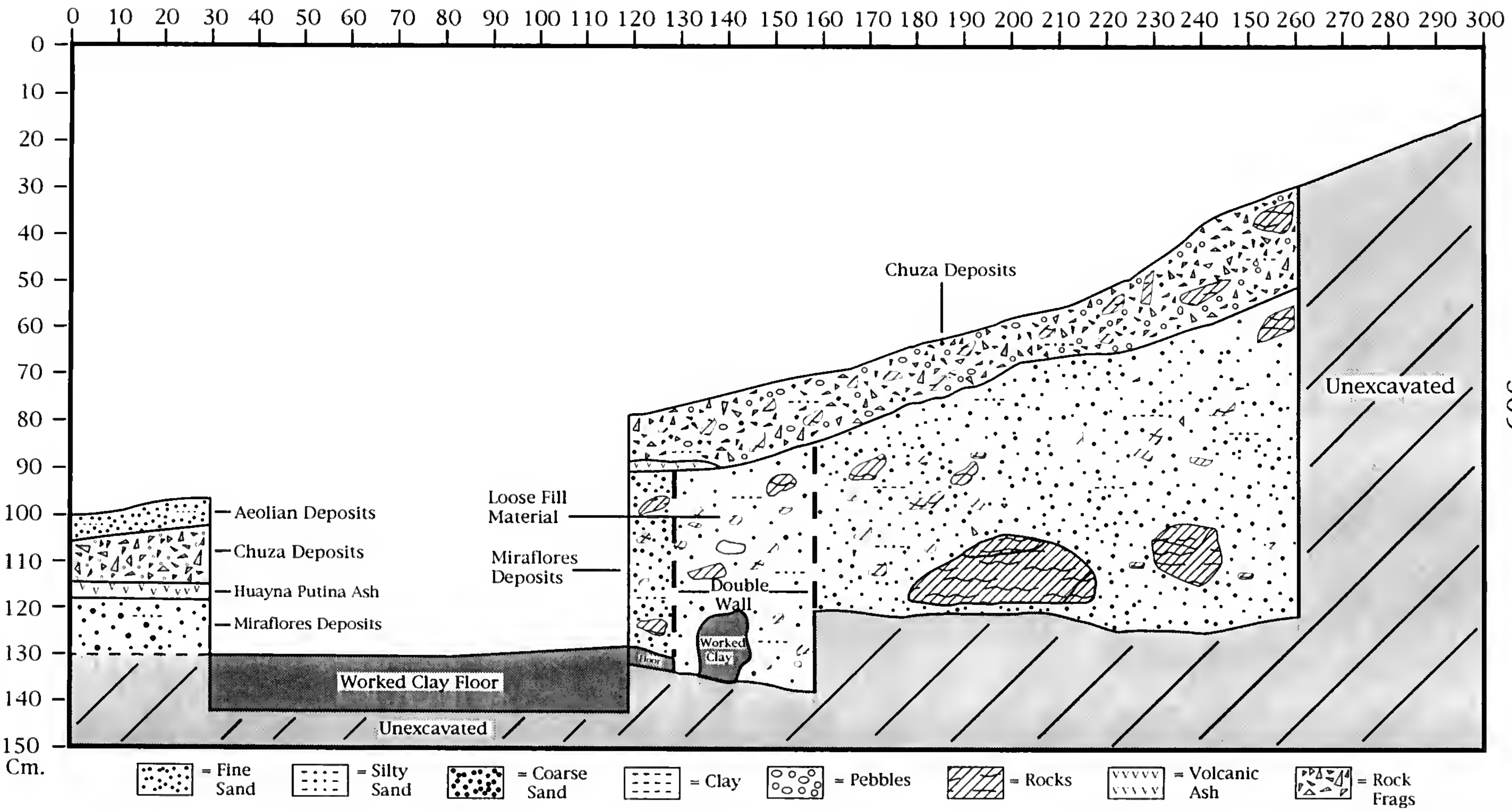
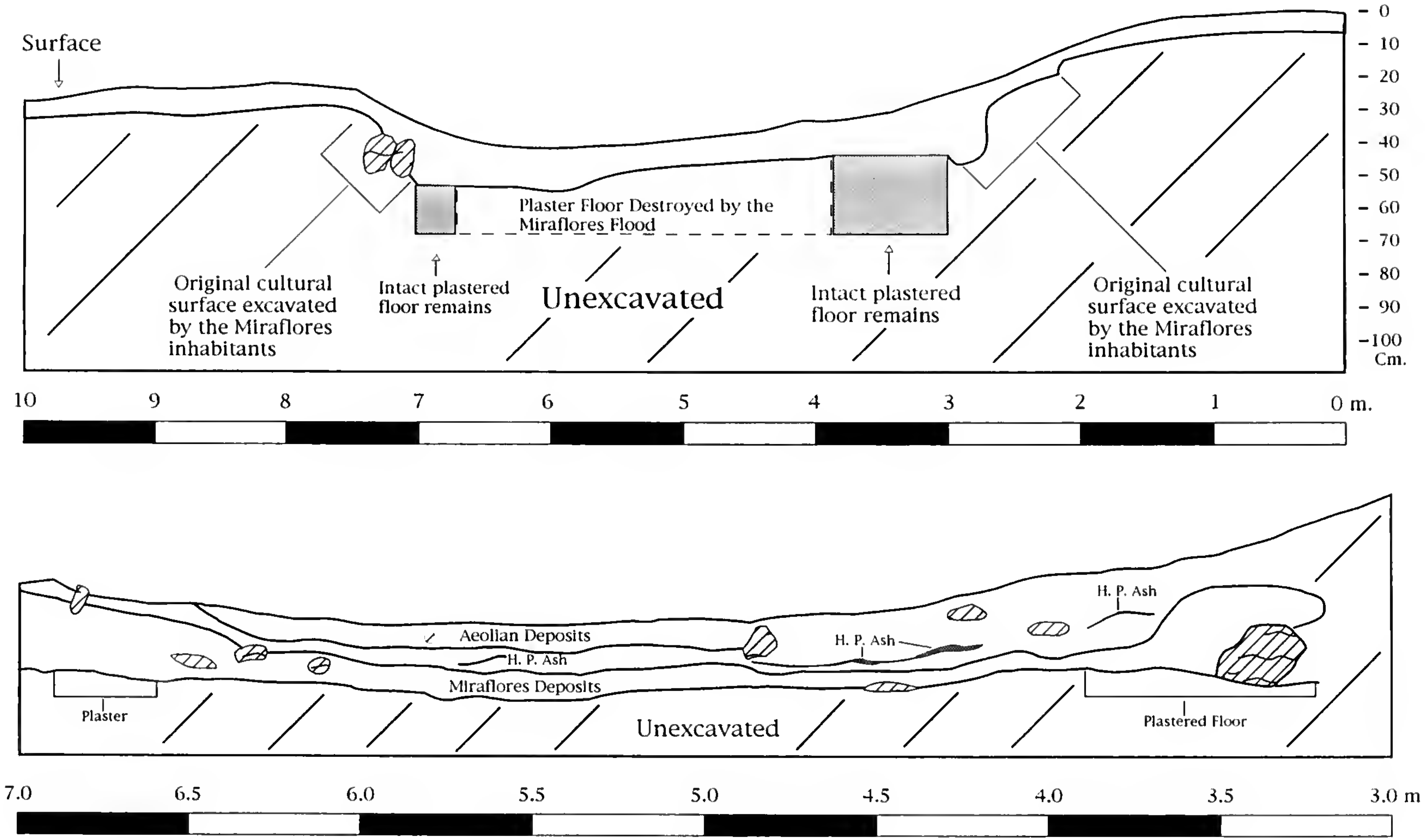


Figure 7-10: North Wall of Large Unit #1--Miraflores Quebrada

was also found overlying the Miraflores deposits. At the left side of the profile drawing, the Miraflores deposits are only 10 cm deep, while those deposits on the right side are at least 50 cm thick. This disparity in depth can be explained since the action of the Miraflores flood surge would be analogous to an ocean wave as it "breaks over" any obstacle. Much of the water is immediately dropped from the main body of the wave, thus losing most of its volume, speed, and depth, as the much shallower water continues it forward motion. This is what probably happened when the Miraflores flood surge flowed over the east wall of Pit #1. Some flood debris was deposited nearer the wall, while more debris struck the center of the pit and then quickly rushed over the west wall, continuing its flow to the ocean.

Further excavations into the Miraflores deposits revealed a 12 cm thick clay floor. The floor on this side of the pit was spared extensive damage by the Miraflores Flood, unlike the centers of the pits shown in Figures 7-11 & -12. The force of the Miraflores flood is evidenced by the fact that the clay floors at the center of both Pits #1 & #2 have been severely damaged and abraded by the flood debris. Even the edges of the floor on the east side of Pit #1 are a little rough, perhaps, from flood scouring.

Beneath the Chuza deposits and sandwiched between the Miraflores deposits was a section of what appears to be strong brown (10YR 4/6) loose fill material for a 30 cm wide wall that perhaps was once located on this side of the sunken feature. The fill material consisted of silt with some sand and clay, small pebbles (3 cm or less), and a few larger rocks up to 10 cm. This material had to have



Detail of Sunken Feature #1

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Figure 7-11: East Profile of Sunken Feature #1--Miraflores Quebrada

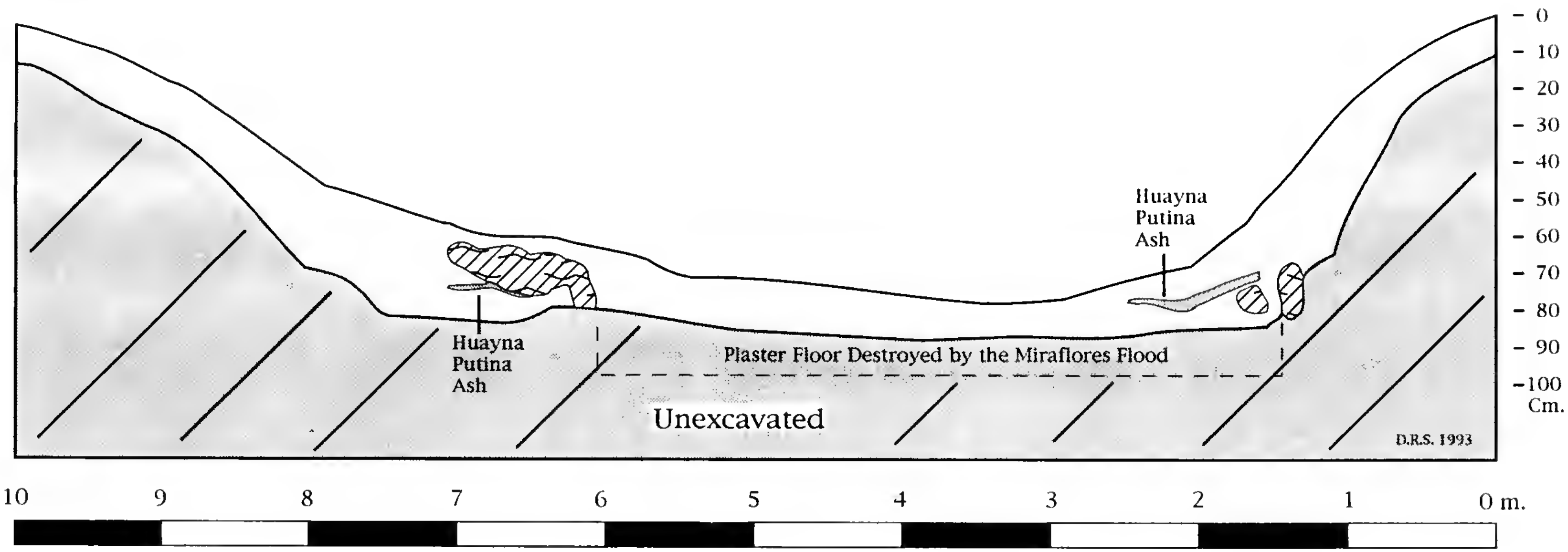

Figure 7-12: East Profile of Sunken Feature #2--Miraflores Quebrada

been used as fill between the sides of the wall since it was totally unconsolidated and could be easily removed with bare hands. There were some large stones (10-20 cm) which could have come from an exterior "wall" or from a seating bench, that could have sat about 15 cm above the floor and had a depth of 11 cm, based on the analysis of the remains. This premise is based on the fact that at the east edge of this sunken feature there were a number of rock imprints (18 cm above the level of the floor) left in the well-preserved worked clay, which were obviously not part of the 12 cm thick clay floor. The presence of large chunks of clay and worked stones leaves the impression that there might have been a "wall-fall" caused by the Miraflores Flood.

Figure 7-13 is a profile of Unit #4 W., which is located very near the southern rim of the quebrada about 10 m from the edge of the marine terrace where it drops sharply to the beach. As evidenced by the profile, this unit lies beyond the limits of the Chuza Flood. The 6-10 cm of strong brown (7.5YR 4/6) aeolian deposits of very silty sand with some clay particles directly cover the Miraflores sediments. The brown (10YR 4/4) Miraflores debris consists of very silty sand, some rock fragments, small rocks (3-5 cm) and a couple of 8 and 20 cm larger rocks suspended in a very hard, salt-impregnated caliche matrix. The strength of the Miraflores Flood is manifested by the inclusion in the flood deposits of several worked, facing rocks from the terraces hundreds of meters upslope.

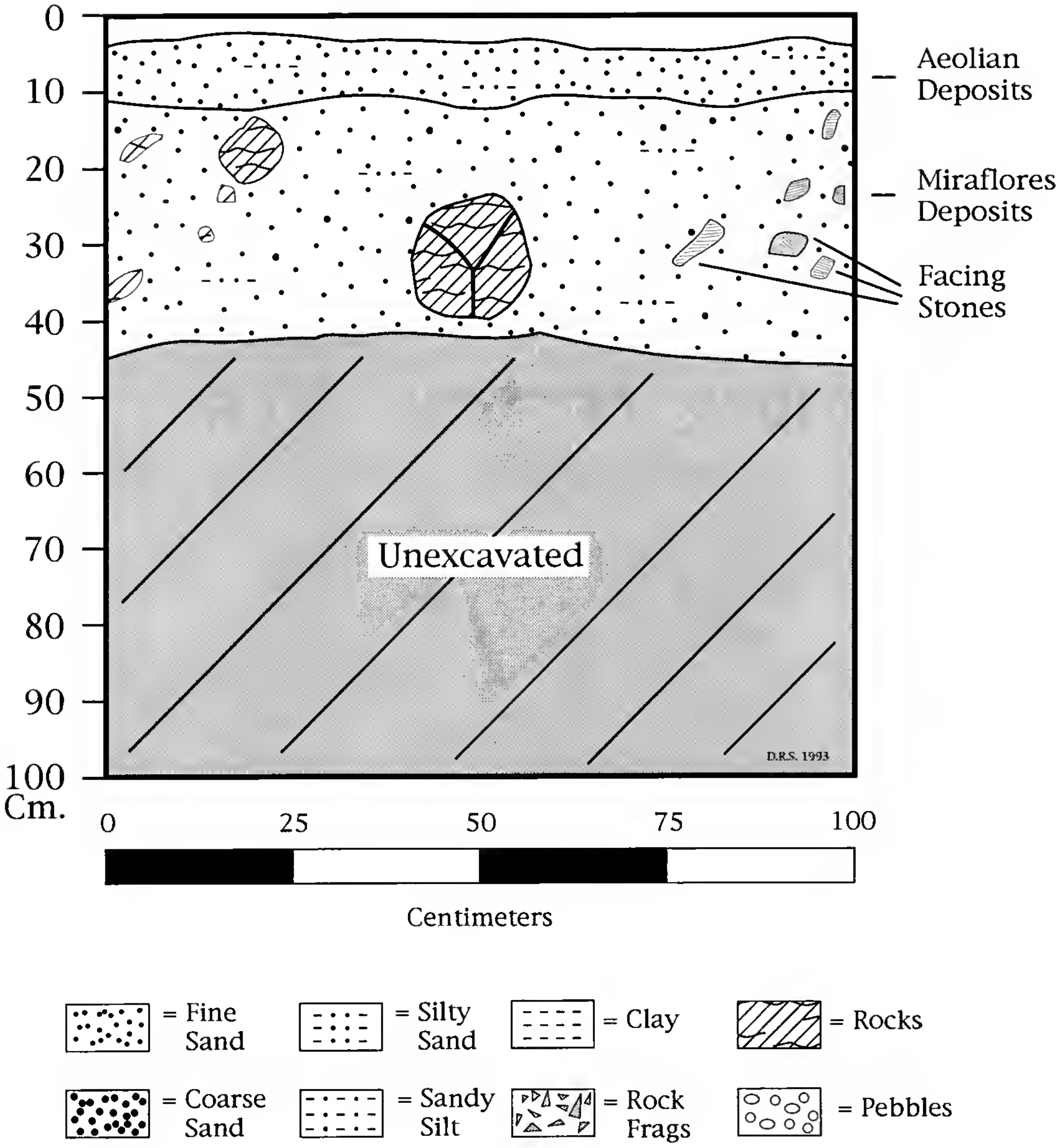

Figure 7-13: East Wall of Unit #4 W.--Miraflores Quebrada

Figure 7-14 is the profile of Unit #5 West, which is located in a 1.5 m deep swag south of Unit #4 W. The color of the aeolian layer has shifted from the previously found brown color to a yellowish red (5YR 5/6) 6 cm thick layer of silty sand with a high clay content. Once again there are no Chuza deposits found in this unit's profile. The dark brown (7.5YR 3/4) Miraflores deposits extend down to at least 62 cm, where excavations stopped. The first 24 cm of the very humid Miraflores deposits was much darker than the remaining 38 cm of this stratum, and it contained a greater amount of silt and clay. This layer looks like true soil because some of these silts probably came from the agricultural terraces. In addition to the commonly included silt and sand, the Miraflores deposits also contained a number of sizable rocks as large as 25 cm with the average being 15 cm. A very dark gray (7.5YR 3/0) feature is present in this unit. This 40 cm by 12 cm feature was comprised of very little silt and extremely fine black, sand-like particles, which were later identified as manganese. There was also a small pocket of carbon present in the upper portion of this same feature.

Figure 7-15 is the profile of 1 by 2 m Trench #1 W. located at the very edge of the marine terrace (Figure 7-14). The yellowish red (5YR 4/6) humid aeolian deposits consisted of silty sand with good clay content and some 1-2 mm decomposed rock particles. The wind-borne materials covered both the Miraflores sediments and two 2-3 cm thick pockets of pinkish white (5YR 8/2) Huayna Putina ash. The tephra was probably preserved because the Chuza Flood

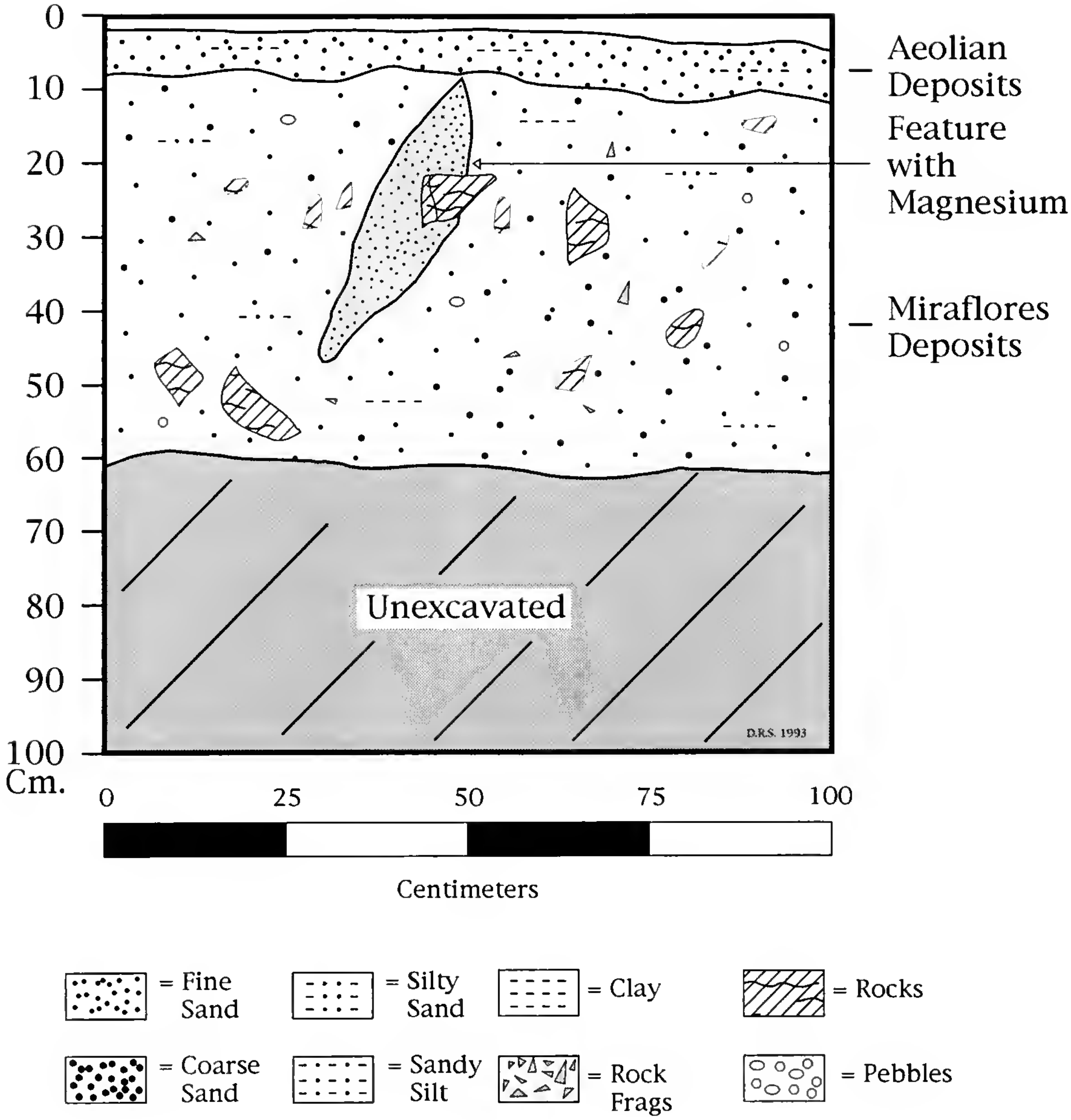

Figure 7-14: East Wall of Unit #5--Miraflores Quebrada

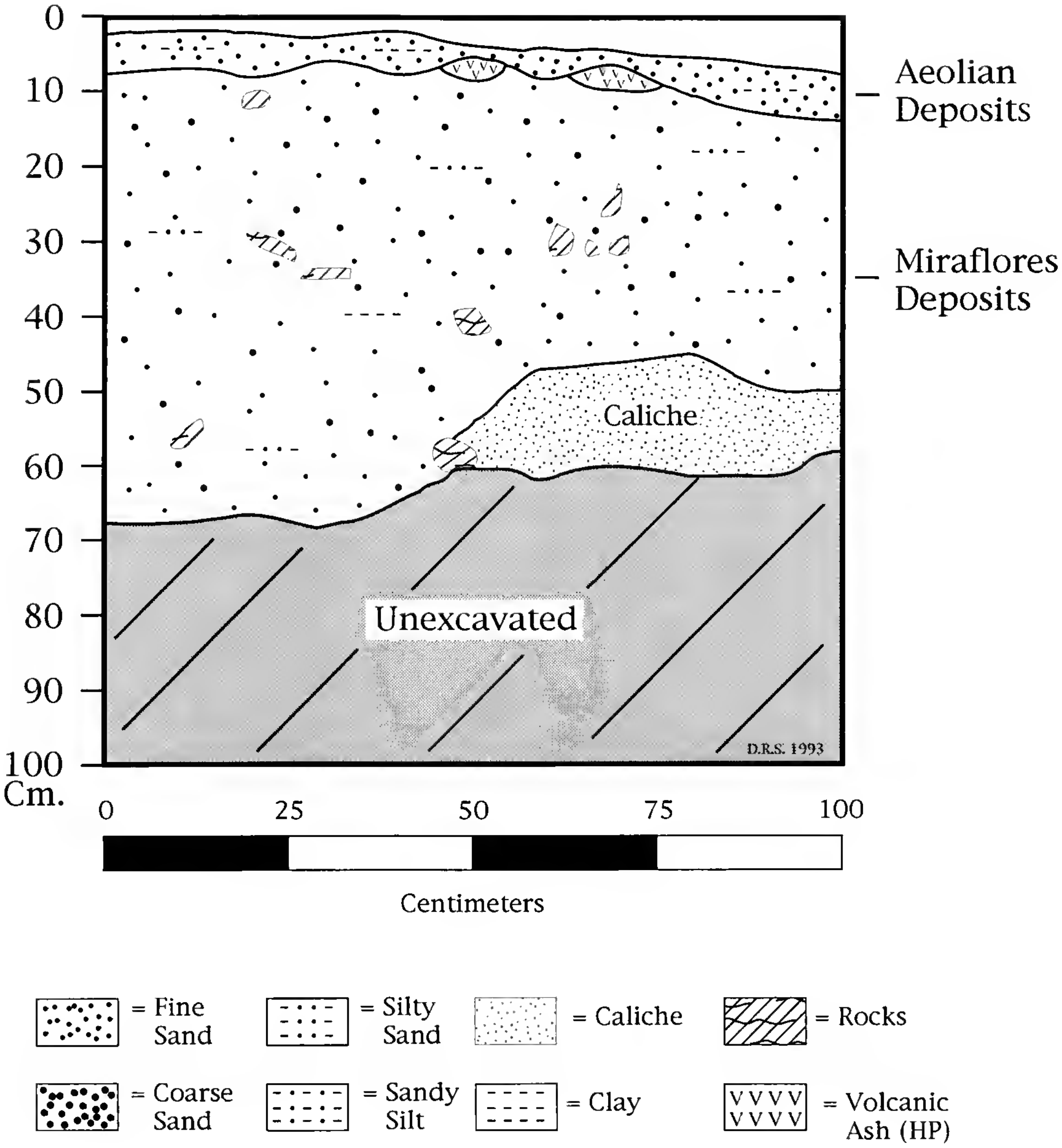

Figure 7-15: East Wall of Trench #1--Miraflores Quebrada

did not reach this location. The dark brown (7.5YR 3/4) Miraflores deposits consisted of extremely humid, very silty sand with clay particles. The deposits continued to 70 cm below the surface, with the lowest 20 cm of deposits being very hard caliche. The fact that these deposits are less than 50 cm shallower than those deposits found at the sunken features again stresses the speed and magnitude of the Miraflores Flood.

Figure 7-16 is the floor plan of Trench #1 West. The deposits in the very bottom of the trench were even harder than those previously encountered because of the very high salt content. The reason for including this floor plan is to emphasis the fact that the Miraflores Flood still contained large 40 cm rocks when its deposits spilled into the Pacific Ocean. Had the settlement at the Miraflores Quebrada been occupied at the time of this event, no one could have survived the fury of the Miraflores Flood.

Miraflores Quebrada

Quebrada Profiles

Figure 7-17 shows the Geologic Column #1 which is located in a small branch of the main quebrada channel east of the modern olive grove. The surface of this column is a grayish brown (10YR 5/2) .5 cm layer of silty sand with 2 mm grit deposited by the 1982-83 El Niño, which covered all other strata, including the Basal Sequence. Located immediately below this layer are the dark yellowish brown (10YR 4/4) aeolian deposits of sand with very little silt. The aeolian

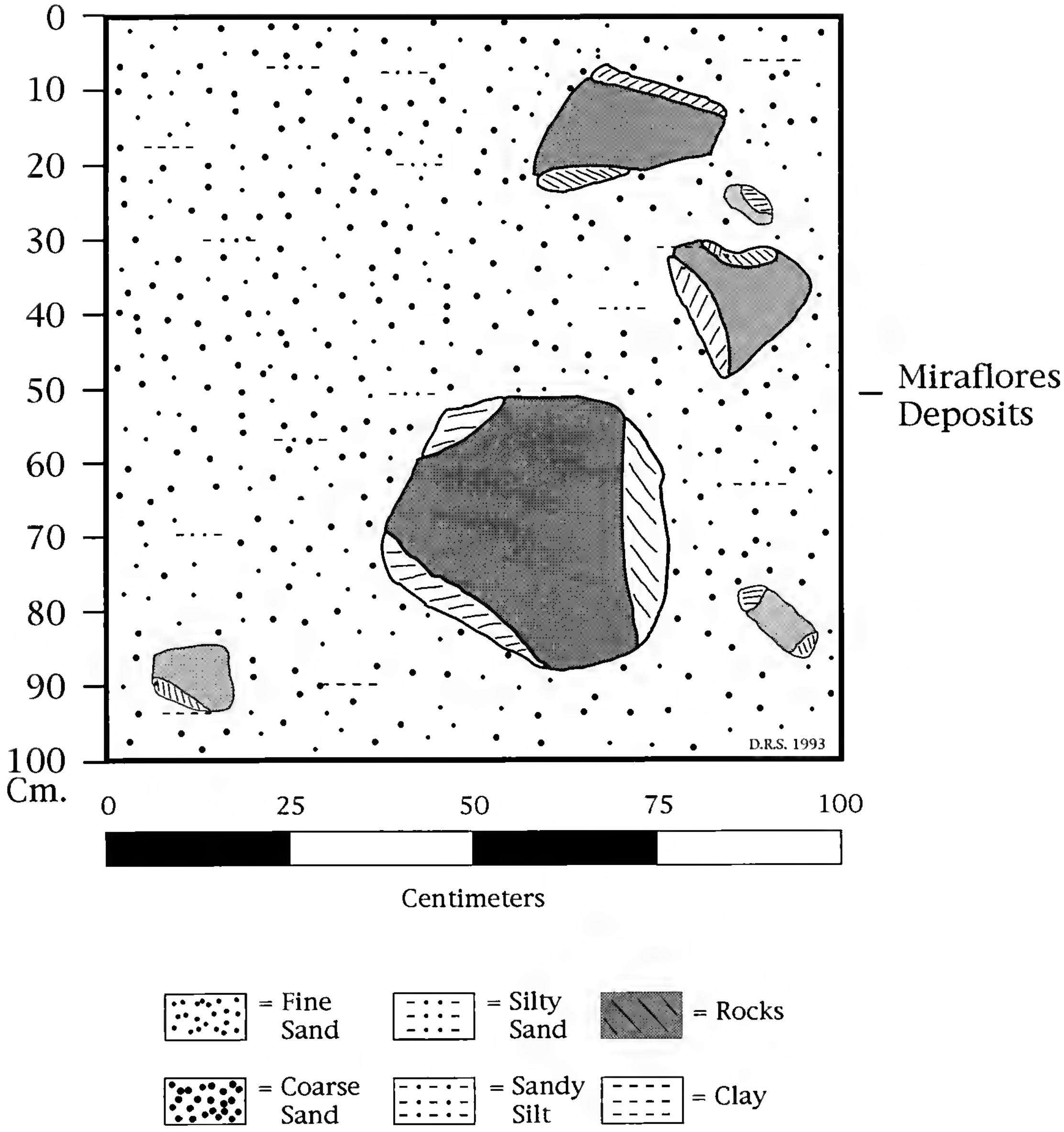

Figure 7-16: Floor Plan of Trench #1 W.--Miraflores Quebrada

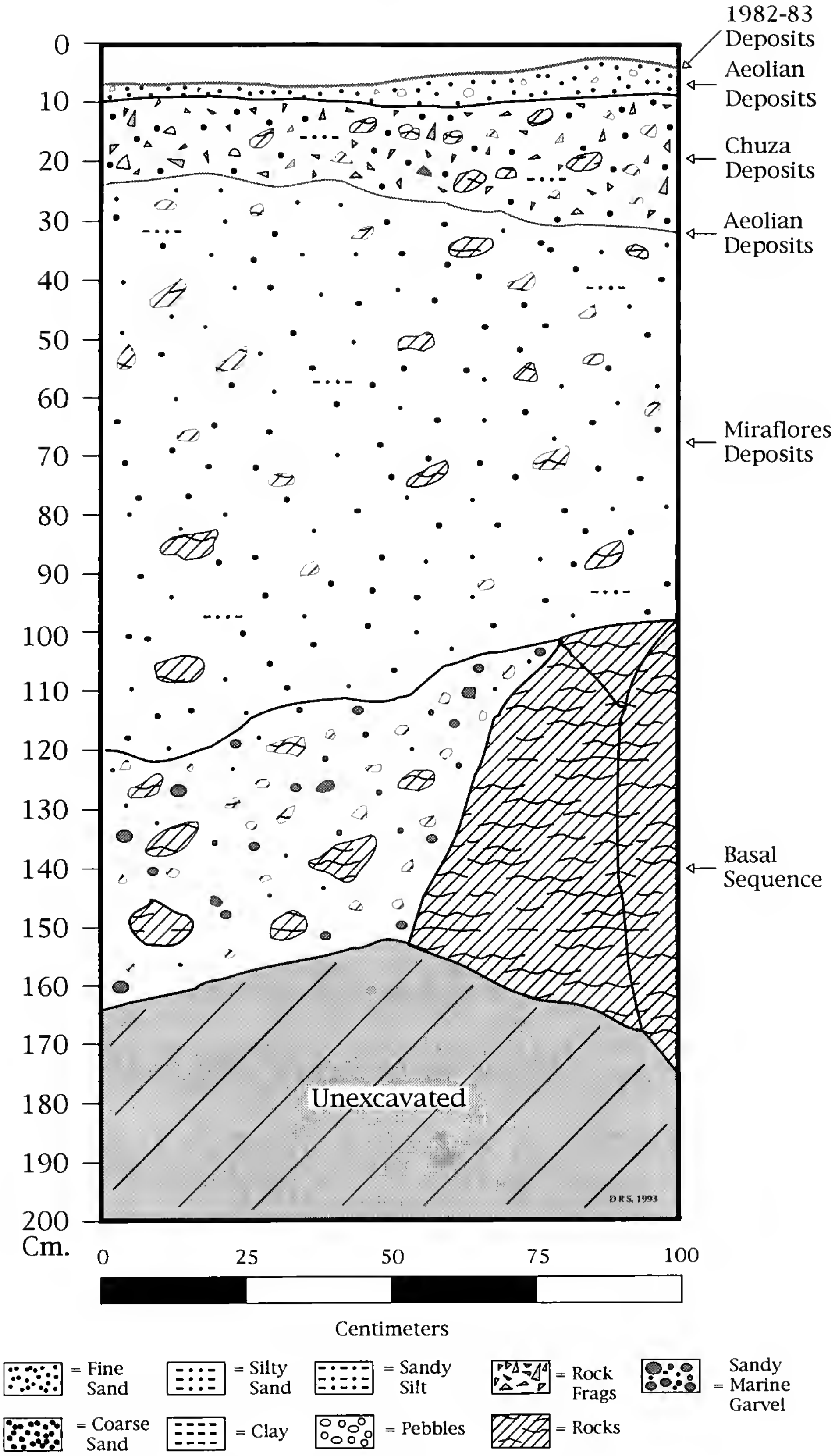

Figure 7-17: Geologic Column #1--Miraflores Quebrada

deposits overlie the 15-20 cm dark yellowish brown (10YR 3/4) Chuza flood sediments consisting of much grit (less than 5 mm), some 3 cm or less rock fragments, and rocks up to 7 cm in length, suspended in a very compacted matrix of silty sand. What appears to be .25 cm of brown (10 YR 5/3) aeolian sand with very little silt separates the Chuza and the Miraflores deposits. Since there are no agricultural terraces upslope that could have provided silts and refuse which could have altered the coloration, once again, there are one meter thick, classic pinkish gray (7.5YR 6/2), extremely compacted Miraflores deposits consisting of silty sand with many rocks, but none of them larger than 8 cm. The reason that the larger rocks are conspicuously missing from the Miraflores deposits, which often include immense rocks and boulders, is because there were none available for flood transport in this small quebrada. Directly below the Miraflores deposits is another thin (1 cm) layer of aeolian materials consisting of brown (10YR 5/3) sand with a little silt. This third aeolian layer overlies the brownish yellow (10YR 6/8) Basal Sequence which consists mainly of coarse sand, very little silt, gravels, and rocks from 6 to 80 cm in length. The Basal Sequence continues uninterrupted down to the bedrock of the quebrada channel bottom.

Figure 7-18 is the Geologic Column #2 located in the main quebrada channel one kilometer upvalley from the olive grove. The surface of this column is covered by the reddish yellow (5YR 6/8) very silty sand of the deposits from the 1982-83 El Niño. Undoubtedly, the 25° slopes at this location helped to contribute to

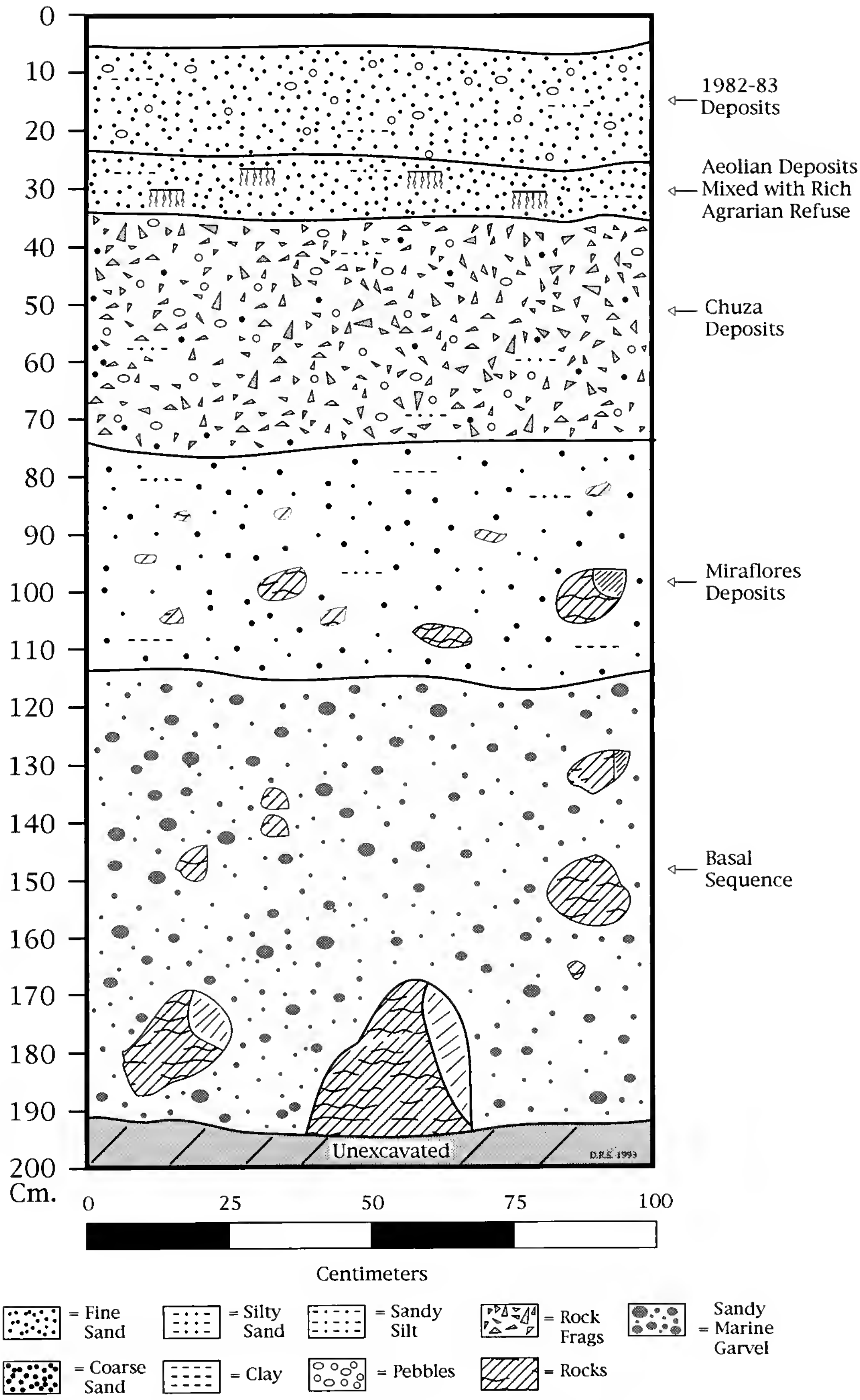

Figure 7-18: Geologic Column #2 at Miraflores Quebrada

the 20 cm deep sheet wash, which is the thickest deposits from this event yet seen by this author. The 10 cm thick aeolian layer, capped by the 1982-83 sediments, is composed of dark yellowish brown (10YR 4/6) deposits which include very fine silty sand and some clay mixed with fine organic remains from the agricultural surfaces located upslope from the column. The 40 cm of slightly compacted dark yellowish brown (10YR 3/6) Chuza deposits are also composed of silty sand, but they also include small pebbles (5 mm or less) and hundreds of rock fragments measuring 2 cm or less. As always, the Miraflores sediments are situated immediately below the Chuza deposits. The 40 cm thick, very compacted, dark reddish grey (7.5YR 4/2) Miraflores sediments consist of silty sand with a few rocks up to 8 cm in diameter. The 80 cm of dark brown (7/5YR 3/4) materials of the Basal Sequence include sandy marine gravels with large rocks up to 25 cm in diameter. The 13 cm of yellowish red (5YR 5/6) 1991-92 El Niño deposits are composed of sandy silt with some fine grit (1-2 mm), which are clearly plastered over the Basal Sequence and the bottom of the Miraflores Flood deposits.

Pocoma Quebrada

Unit Profiles

Figure 7-19 is the profile drawing of a one meter section of the Terrace Wall #1 supporting a domestic/agricultural terrace. As previously stated, this location provided one of the few examples of rebuilding by the survivors of the Miraflores Flood. The 4-14 cm thick brown (10YR 5/3) aeolian deposits, consisting of very fine silty sand with some organic matter, included a 4 cm by 30 cm pocket of

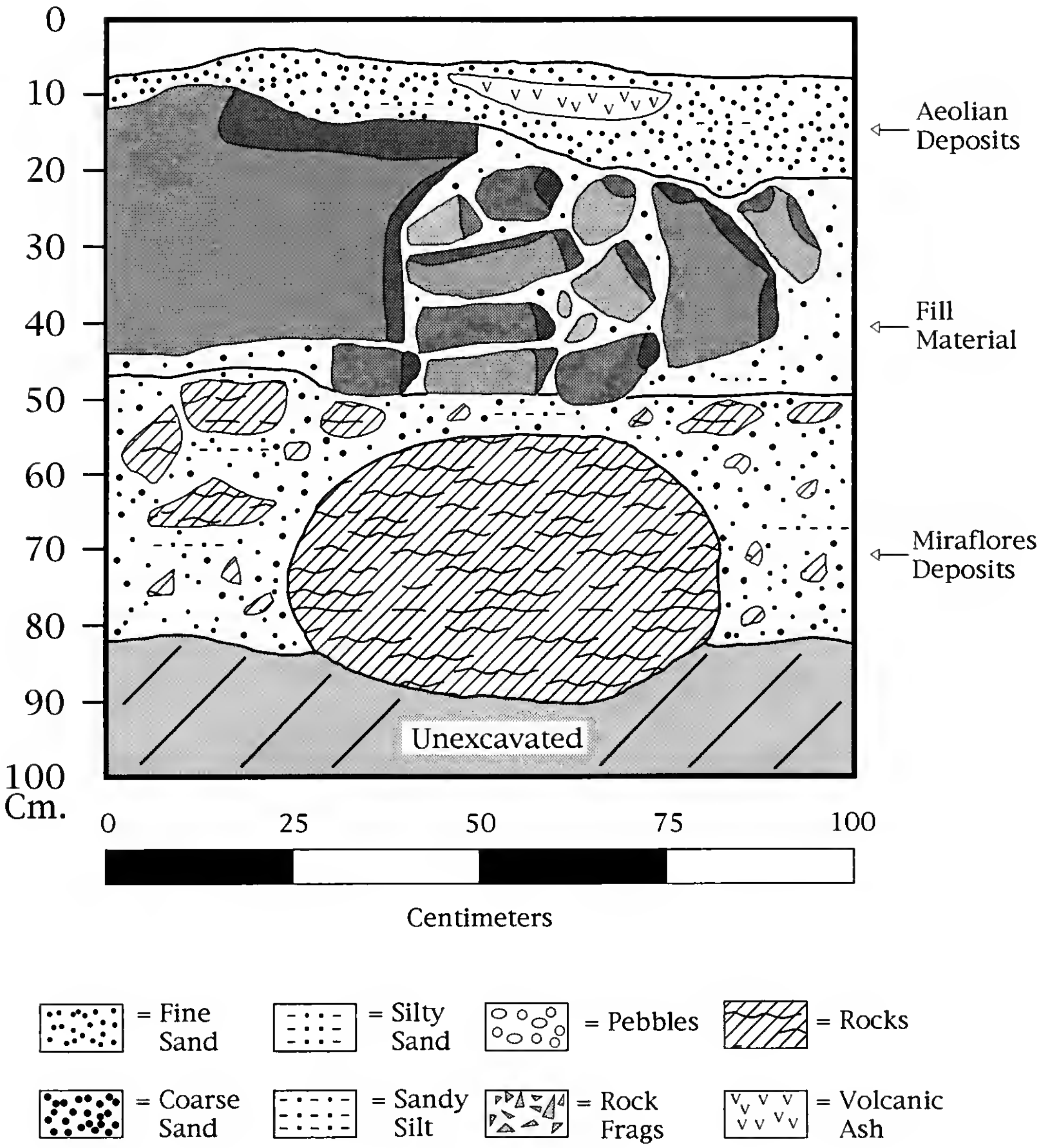

Figure 7-19: Profile of Terrace Wall #1 at Pocoma Quebrada

light gray (10YR 7/1) Huayna Putina volcanic ash, which was shielded by the terrace wall. Immediately beneath the aeolian layer are the terrace wall support stones, which are as large as 35 cm by 50 cm. The very large stone on the left of the profile drawing has a number of smaller stones neatly coursed against it. In between these smaller stones is the dark brown (10YR 4/3) fill material, which is composed of very fine silty sand and clay with some small seashell fragments, roots, and other organic matter, which continues downward until it meets the Miraflores deposits. The constituents of the reddish brown (5YR 5/4) Miraflores deposits at this location are the same as those deposits found at other locations. The deposits are composed of a high sand content with very little silt, many small rocks, some rock fragments, and a number of large rocks, including one large boulder measuring almost 60 cm in diameter.

At the left side of the profile, between 44-47 cm, are some of the Miraflores deposits which were not excavated as deeply as the other flood deposits shown in the remainder of the profile. The craftsmanship of the Chiribaya builders is vividly shown in the construction of the terrace wall, since some of the deposits were obviously removed so a stone "shim" could be used to level the very large, flat polygonal facing stone.

Figure 7-20 shows the floor plan of Unit #2 located about 15 m from the Terrace Wall profile. The floor plan shows a cane (and probably daub) wall sunk into the Miraflores deposits, running diagonally across the 1 m unit. Horizontal support canes, varying 1-2 cm in diameter, were also found *in situ* and are represented by the

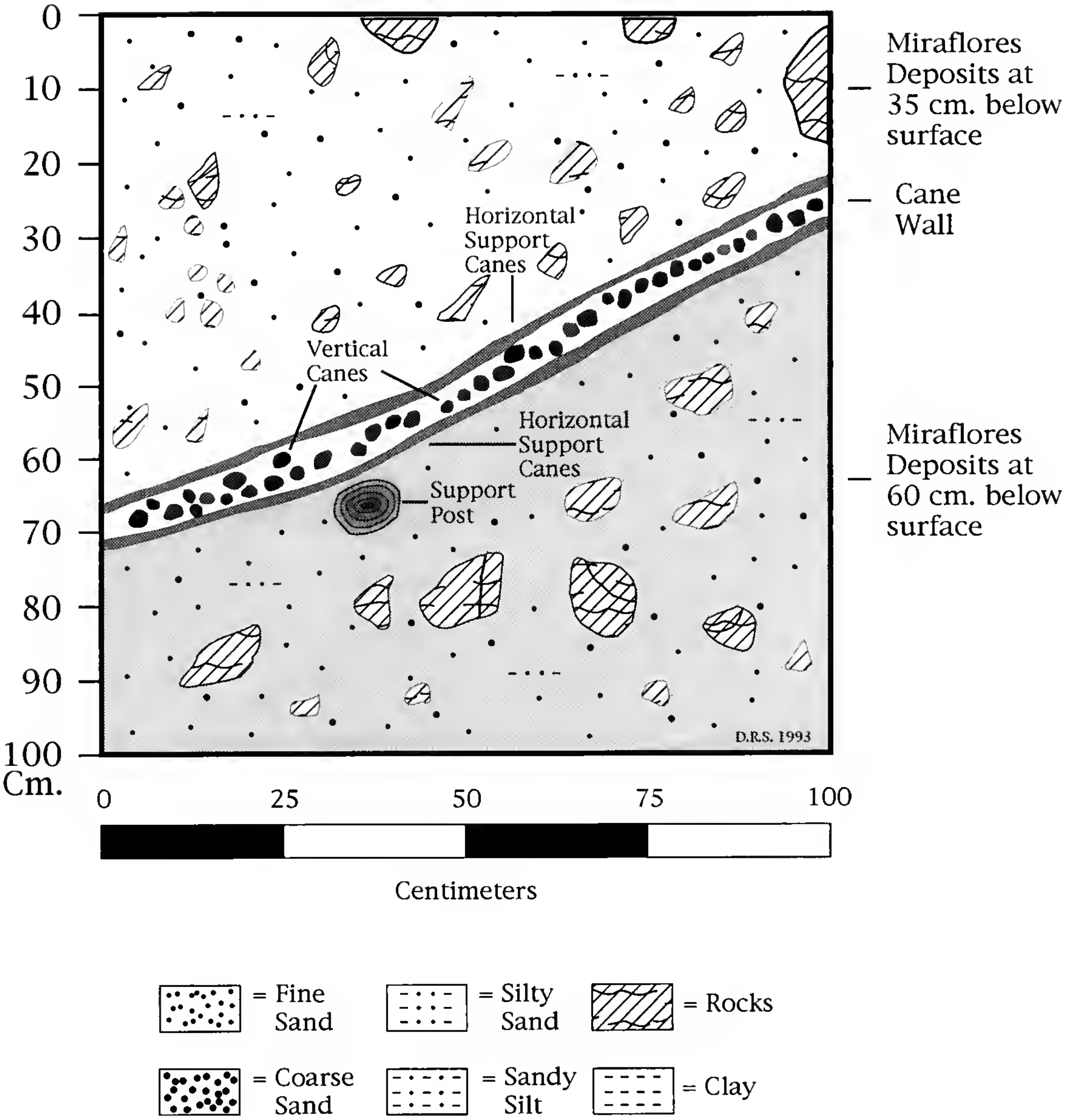

Figure 7-20: Floor Plan of Unit #2--Pocoma Quebrada

shaded irregular lines above and below the 1-3 cm vertical canes, represented by the very dark, filled circular shapes. Adjacent to the cane wall is a 9 cm wide post, presumably made of Molle wood, possibly used to support the roof for this structure. Analysis of the artifactual remains (see Chapter 6) leads to the conclusion that this structure was a domestic dwelling. The Miraflores deposits at the top of drawing, above the cane wall, are located 35 cm below the surface, while the deeper deposits below the cane wall lie 60 cm below the surface.

Figure 7-21, a cross section drawing of Unit #2, graphically shows the involved stratigraphy of this unit. The upper Miraflores deposits are located on the left of this figure, while the lower flood sediments, which were beneath the house floor and occupation debris, are shown at the right side of the figure. The 25 cm thick stratum of occupation midden overlying the flood deposits clearly evinces that the flood deposits had to have been dug out to allow the installation of this wall, whose canes rest in a small trench cut into the sediments.

Canal Profiles

Figure 7-22 is the profile of the #2 High North Canal exposed by a trench dug into this intake canal located near the spring source for the irrigated agricultural system. The uppermost deposits are the yellowish brown (10YR 5/6) wind transported very fine silt with some sand and 1-2 mm pebbles. Beneath the aeolian deposits is the strong brown (7.5YR 4/6) 1982-83 El Niño sheet wash (8 cm at its

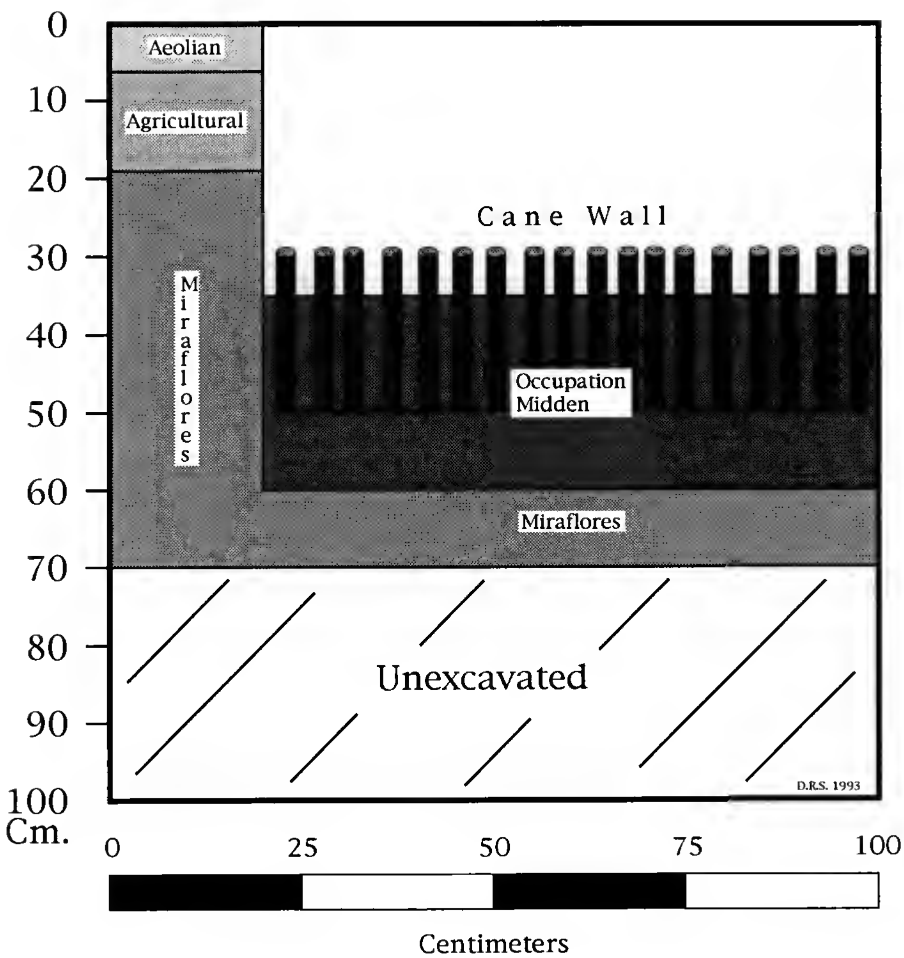

Figure 7-21: Cross-Section of Unit #2 at Pocoma Quebrada

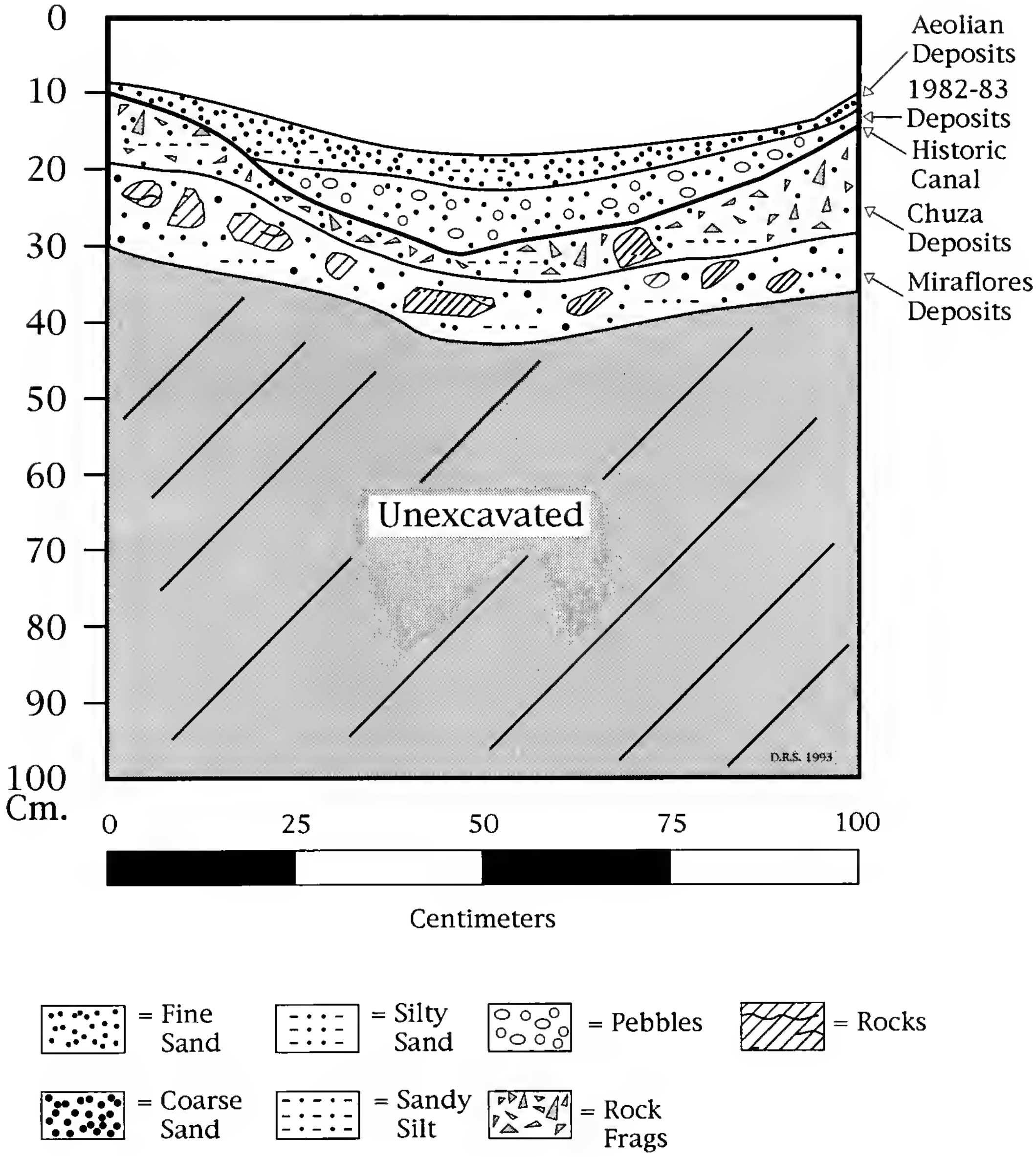

Figure 7-22: #2 High Canal--North Side of Pocoma Quebrada

thickest) which consists of coarse sand with very little silt and some 3-5 mm grit. This sheet wash fills a concave depression, which appears to be an historic irrigation canal bottom which was dug directly into the Chuza deposits, which consist of 10-15 cm of dark grayish brown (10YR 4/2) sandy silts with small pebbles, rock fragments, and a few rocks up to 8 cm wide. The Chuza deposits overlie the strong brown (7.5YR 5/6) Miraflores deposits, which extend to an unknown depth, are composed of silty sand, some gravels, and many rocks up to 20 cm in length. It is surprising that the sheet wash found in the canal is not even deeper because the slopes of the quebrada average 30° +/- with some slopes increasing to a 45° angle. This same sharp incline would have helped to increase the speed of both the Chuza and Miraflores events, and, at the same time, would have provided additional finer materials.

The construction design of the canal indicates that it was built by the Chiribaya to irrigate the abandoned agricultural terraces which are situated a few hundred meters downvalley from this point. The canal originally started from the intake point and followed the contour of the quebrada and terminated at the agricultural terraces. The efforts by the Spanish to reactivate this canal, after the Chuza Flood, must have been successful because there are trunks of olive trees scattered along the length of this canal remnant.

Figure 7-23 shows the profile of the #1 High South Canal. This profile contains the most complicated canal stratigraphy encountered during the course of my investigations. The 4-6 cm of yellowish

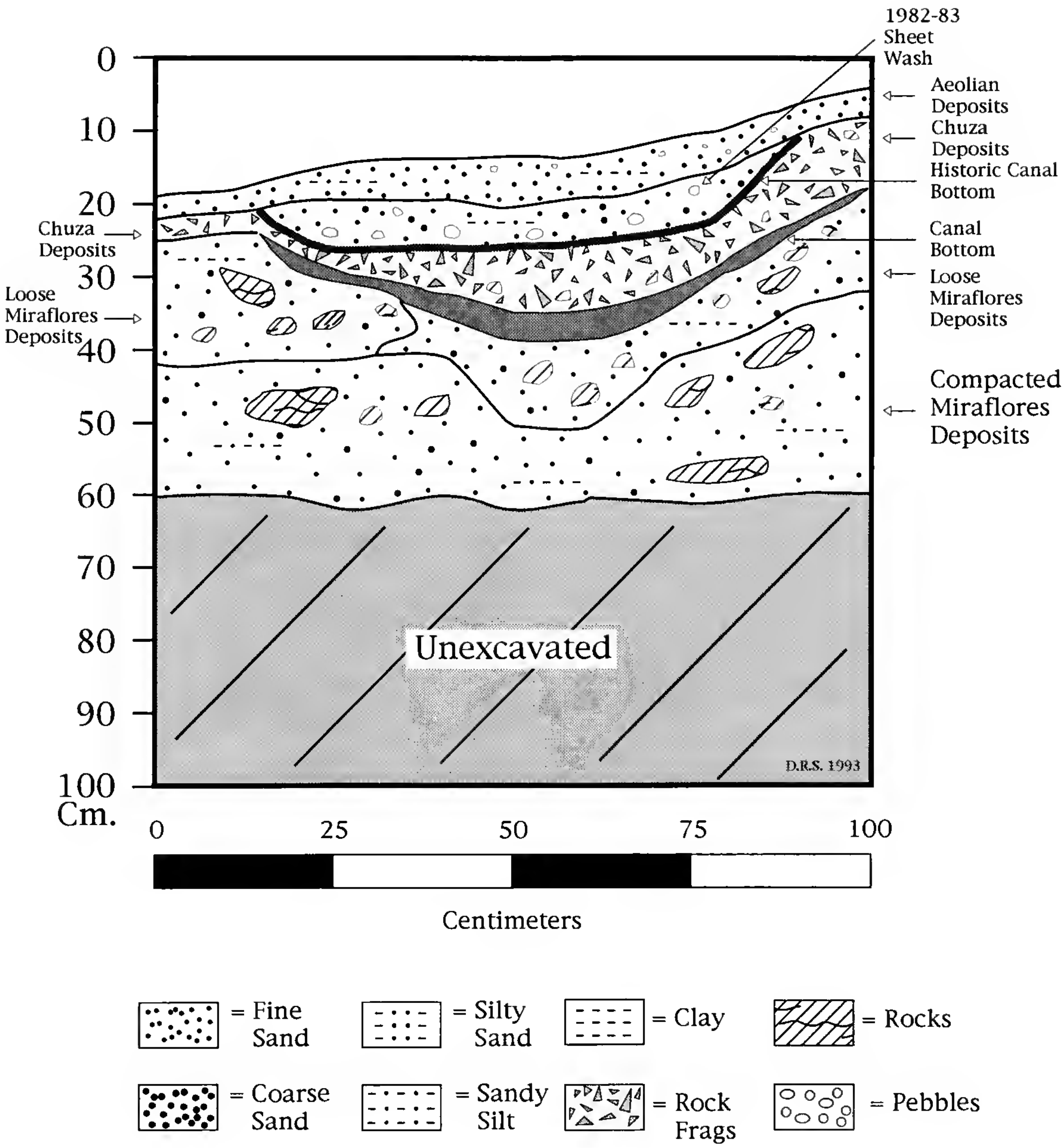

Figure 7-23: Profile of #1 High South Canal--Pocoma Quebrada

brown (10YR 5/6) aeolian deposits of very fine silt with some sand and grit (less than 2 mm) overlie 6 cm of brownish yellow (10YR 6/6) 1982-83 sheet wash comprised of sandy silt and some very small grit, which fills what appears to be the depression of the second historic canal which was dug into prior flood deposits. This canal bottom contains 1 cm of very fine sands and silt. Immediately below the canal bottom are the dark yellowish brown (10YR 4/6) Chuza deposits consisting of silty sand with many small rock fragments and pebbles. Directly beneath the Chuza deposits is the outline of another historic canal bottom filled with both coarse and fine sand and some very small pebbles apparently transported by water. Beneath this canal bottom are reddish yellow (7.5YR 6/6) loose materials composed of sandy silt with some rocks up to 8 cm in size. These loose materials are apparently the result of the vain attempt to excavate yet another canal depression into the Miraflores sediments, which underlie the canal depression. The only difference in the reddish yellow (7.5YR 6/6) sandy silt Miraflores deposits and the loose materials above them is the fact that the undisturbed Miraflores deposits are very compacted and contain some larger rocks up to 15 cm in length.

Excavations revealed that the outside support wall, not shown in Figure 7-23, was constructed with mortarless stonework, consisting of some stones as large as 50 cm. Also not shown, is the inside canal wall, which was cut into the Miraflores deposits, and appears to be plastered smooth with fine silts and clay. This appearance could have resulted from the smoothing action of flowing irrigation water which inherently contains amounts of fine silts and

sands. There is loose fill in between the canal walls and canal bottom.

Since the canal bottom was obviously the result of excavating another irrigation channel directly in the Miraflores deposits, it poses the question of whether the canal was re-activated by the Chiribaya people or whether the new canal was created later by the Spanish Colonialists. Today the canal course follows the contour of the quebrada West and then turns South where it begins to slope downhill. If the canal were all intact, it would terminate a short distance from the modern olive grove.

It is plausible that since there was a remnant Chiribaya population which survived the Miraflores Event here at Pocoma, they may have been able to use some of the agricultural terraces which were not too heavily damaged by the flood. However, unless the extant olive grove or the abandoned olive grove within the confines of the colonial stone wall cover prehistoric terraces, there are no discernible prehistoric terraces which either the #1 Low South Canal or the #2 High South Canal could have irrigated. Therefore, perhaps additional future research in the area of the abandoned olive grove and the visible agricultural terraces will be able to answer definitively the question of who briefly used this canal after the Miraflores Event.

Figure 7-24 is the profile of the #1 Low South Canal. Only 1-2 cm of yellowish brown (10YR 5/4) aeolian silty sand overlie the 8 cm of dark brown (10YR 4/3) 1982-83 sheet wash. Once again there is evidence of an irrigation canal depression, which is now filled by the

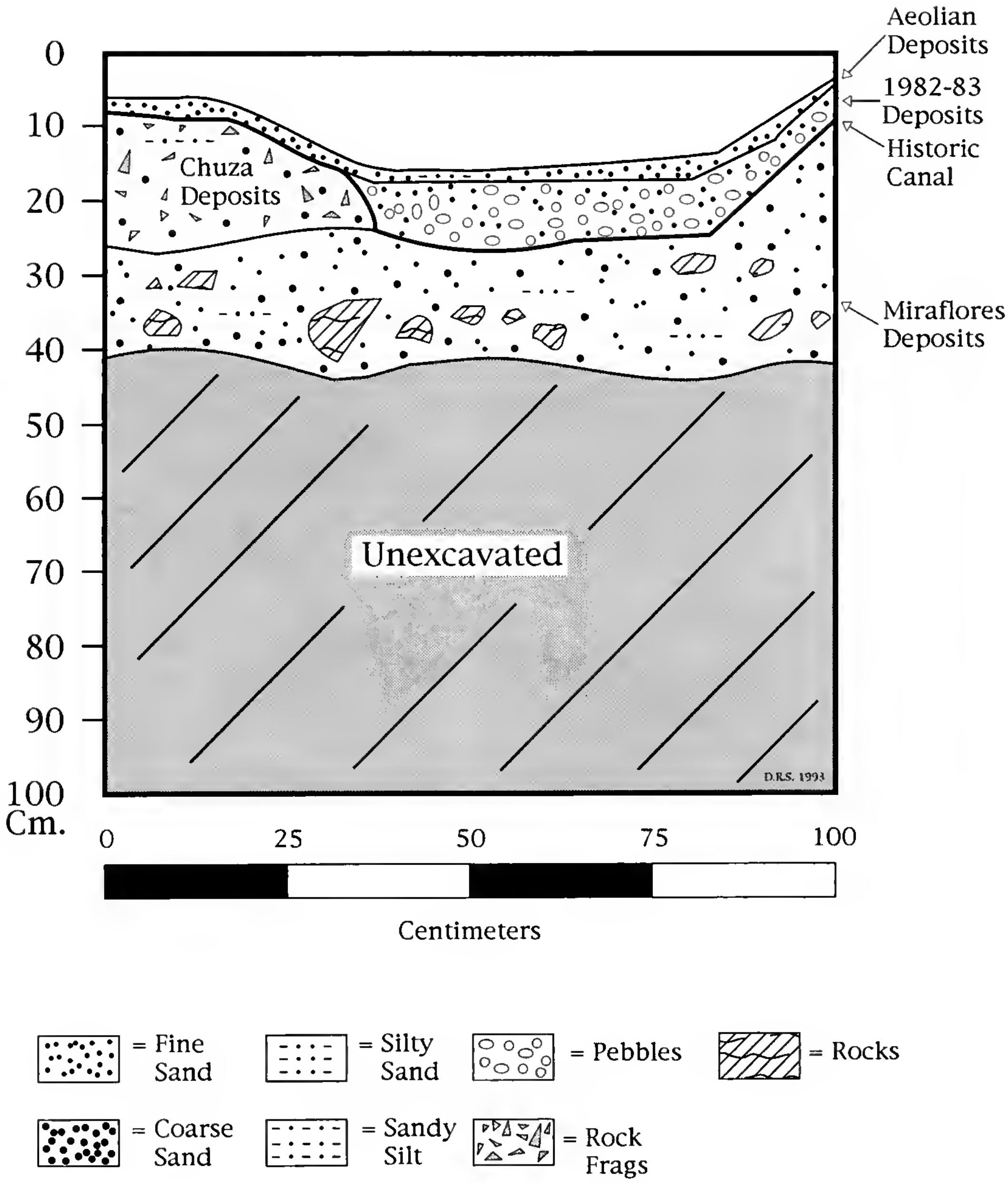

Figure 7-24: #1 Low Canal--South Side of Pocoma Quebrada

1982-83 sheet wash, having been excavated into the reddish yellow (7.5YR 6/6) Miraflores deposits which consists of very compacted silty sand with many small rocks and some larger rocks up to 20 cm in length. The outside wall of this canal is the dark brown (10YR 5/4) Chuza deposits consisting of sandy silt with rock fragments and a few larger rocks. Thus, this canal was probably dug by the Spanish Colonialists some time after the Chuza Flood occurred.

Quebrada Geologic Column

Figure 7-25 is a drawing of the Geologic Column #1 located in a deep cut made by excavating equipment. The top of the column is capped by the yellowish brown (10YR 5/6) aeolian deposits consisting of very fine silt with some sand and small 2 mm pebbles. Beneath the aeolian debris are the dark yellowish brown (10YR 4/6) loose sandy silt deposits of the 1982-83 El Niño sheet wash which includes some small 2-3 cm rocks. Immediately below this stratum are the 10-30 cm deep dark brown (10YR 4/3) Chuza deposits composed of silty sand with many rock fragments and small rocks 5-8 cm in diameter.

The most important feature of this column is the 60 cm thick dark brown (10YR 4/2) occupation midden consisting of silt, sand, clay, and grit. Also included in this midden are many seashells, rock fragments, rocks varying from 6-10 cm, and many root hairs. This midden, which is at least 30 meters wide based on the fact that it was also found in the shovel tests, is testimony to the fact that some Chiribaya people survived the ravages of the Miraflores Flood, and that they occupied this site for quite awhile based on the depth of

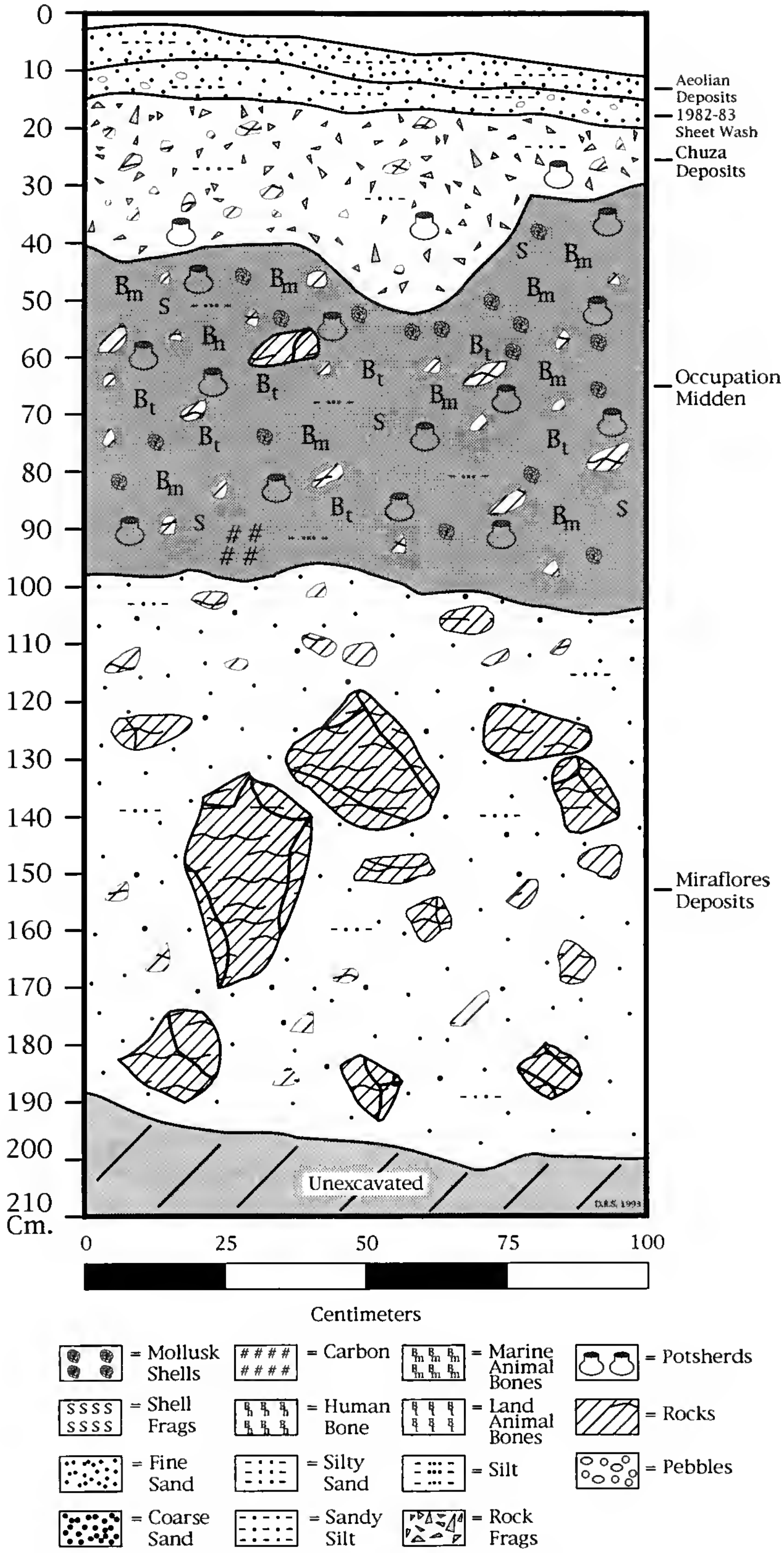

Figure 7-25: Geologic Column #1--Pocoma Quebrada

the cultural deposits. Immediately beneath the midden are the strong brown (7.5YR 5/6) Miraflores deposits with both fine and coarse sand, silt, some gravels, a few angular rocks, and large rocks up to 40 cm in length.

The Ilo Valley

The Tomb Site

Stratigraphic Profile

Although the slope angles (25-30°) in the Ilo Valley are basically the same as those found in the coastal quebradas, and in some cases, even less steep, the Chuza and Miraflores flood deposits in the valley are 4-5 times thicker, in certain places, than those flood deposits found in the coastal quebradas. Figure 7-26 vividly shows the differences in the flood stratigraphy at the Tomb Site located in the upper Ilo Valley about a kilometer downvalley from the "choke point" for the valley irrigation system and approximately the same distance upvalley from Planting Surface #1 (Figure 7-27).

At the top left of Figure 7-27, 10-12 cm of talus debris, which sloughed off the relatively steep granitic slopes, has covered much of the Chuza debris which originated from the lateral quebrada. Directly below the upper Chuza deposits are earlier talus deposits which overlie about 50 cm of Miraflores deposits from the lateral quebrada. More Chuza deposits have encapsulated the lower support wall of the prehistoric Osmore canal with a meter plus of detritus. Shown trapped immediately above the lower canal support wall is a thin lens of Huayna Putina ash which can be seen continuing

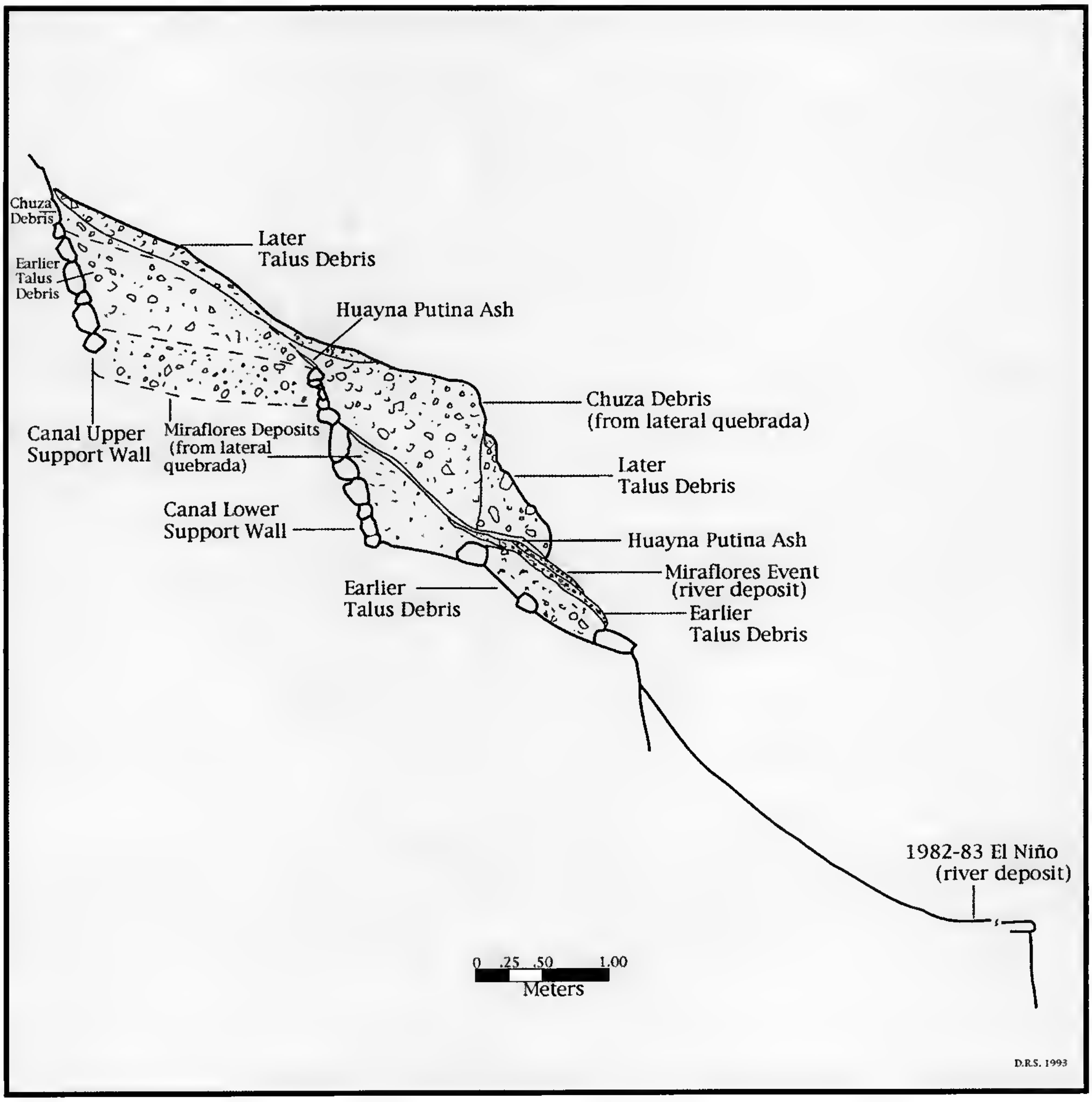

Figure 7-26: Tomb Site at Planting Surface #1, Ilo Valley

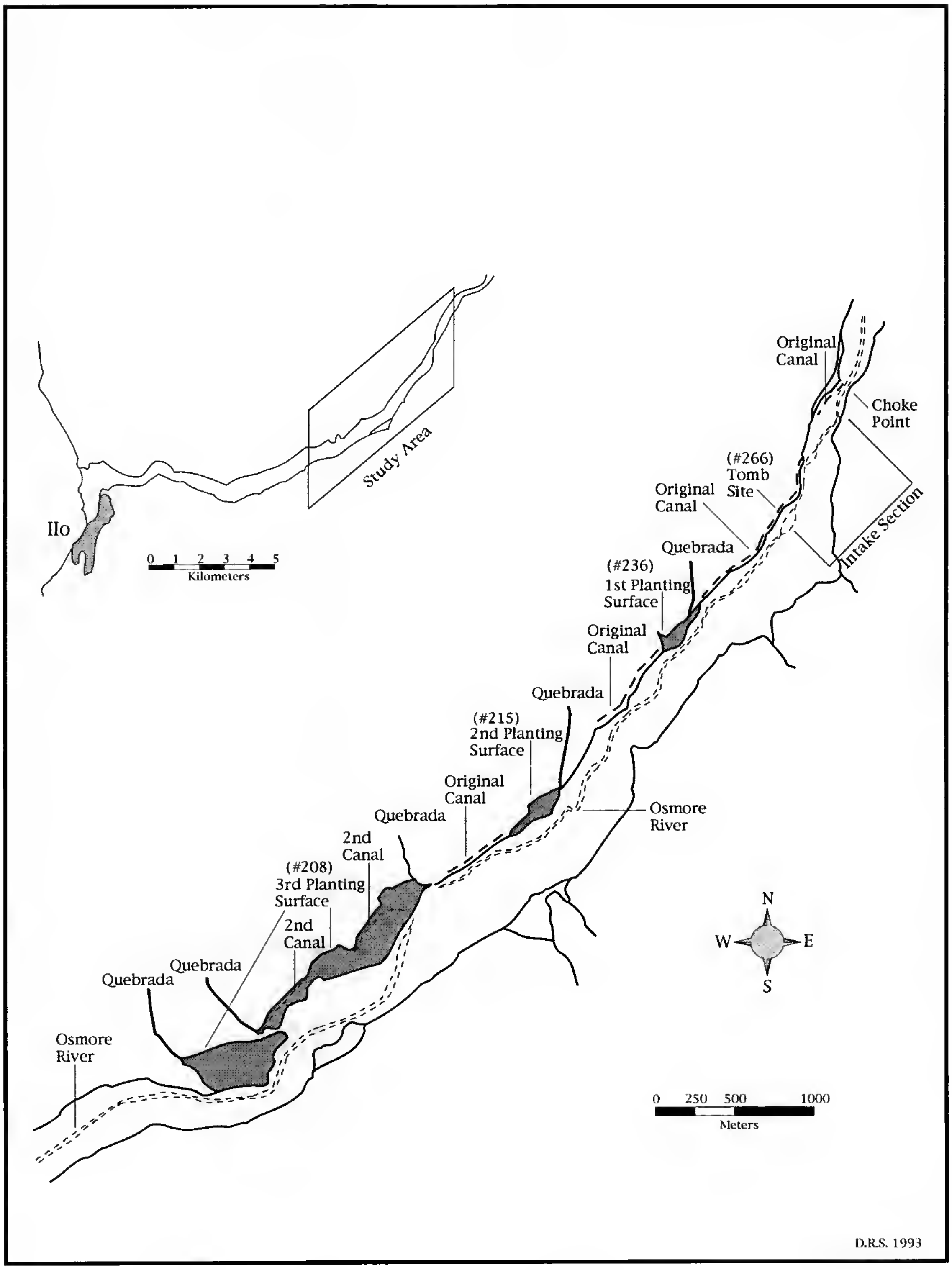

Figure 7-27: Ilo Valley--Lower Osmore Drainage

downslope where it overlies both the Miraflores debris from the adjacent quebrada and the river. At the center of the profile, directly beneath the earlier talus debris, are several stones probably dislodged previously from the canal support walls.

According to this stratigraphy, the Miraflores flood debris first surged down lateral quebrada and later more of the Miraflores sediments were deposited by the river. This sequence is evidenced by the fact that the river-deposited Miraflores sediments overlie the earlier talus debris. Although these river deposits are found over 4 m above the river floodplain, they obviously did not reach the even higher irrigation canal. Rather it was the inordinately large Miraflores flood surge from the lateral quebrada which inundated this "intake" section of the Osmore canal and rendered the irrigated agricultural system totally useless. To further complicate the archaeological problem, the Chuza flood debris later encapsulated the Miraflores deposits and the canal support walls. There are also other quebradas located on the north side of the Ilo Valley which disgorged collateral flood debris that either covered or swept away every section of the canal located along the quebrada walls.

Planting Surface #1

Canal Trench #1

Figure 7-28 is an overview of Planting Surface #1 showing the location of the historic canal in which the trench was dug. Figure 7-29 is a profile drawing of a trench cut into an historical canal at the First Planting Surface about 12 km upvalley from the mouth of the

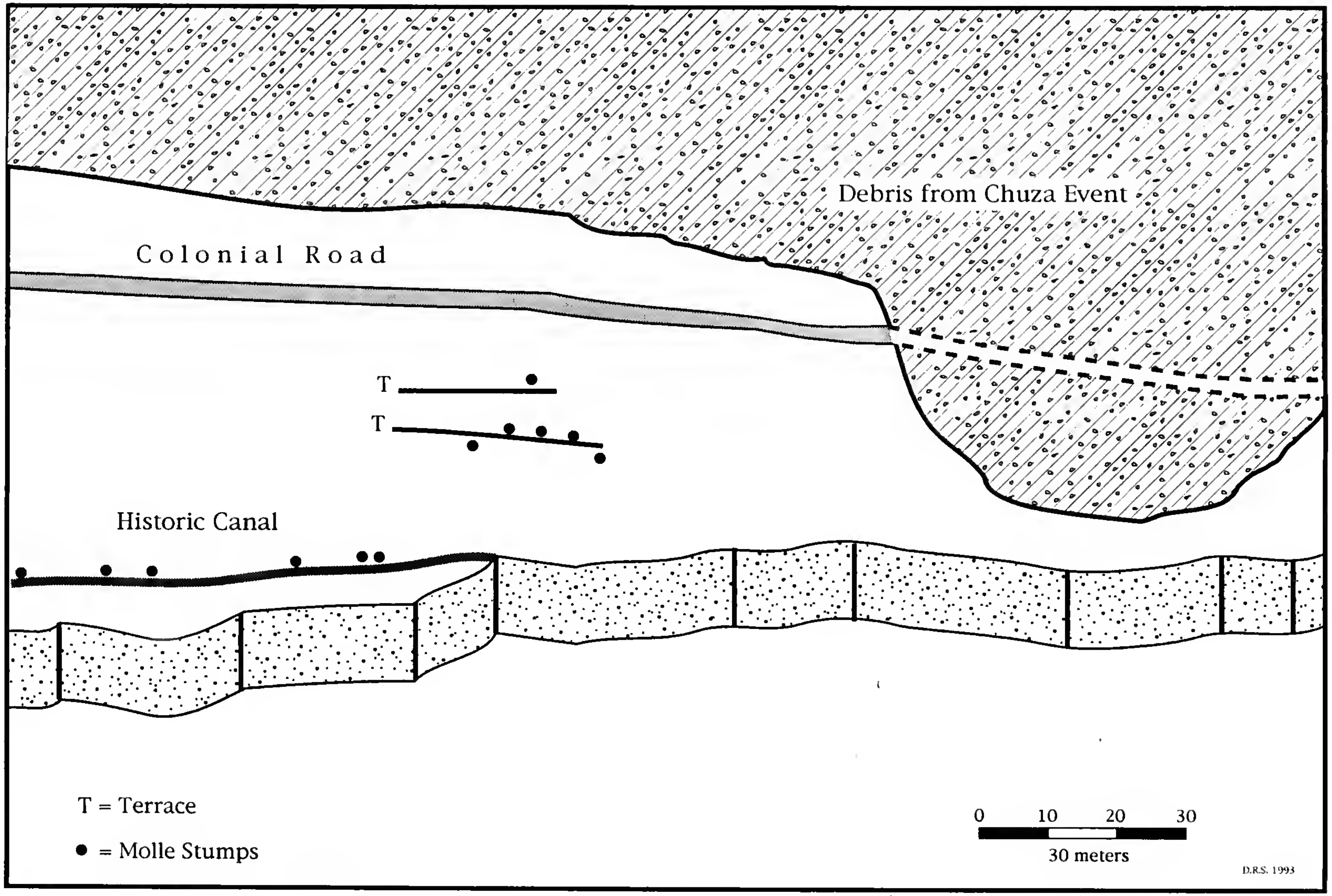

Figure 7-28: Planting Surface #1--Ilo Valley

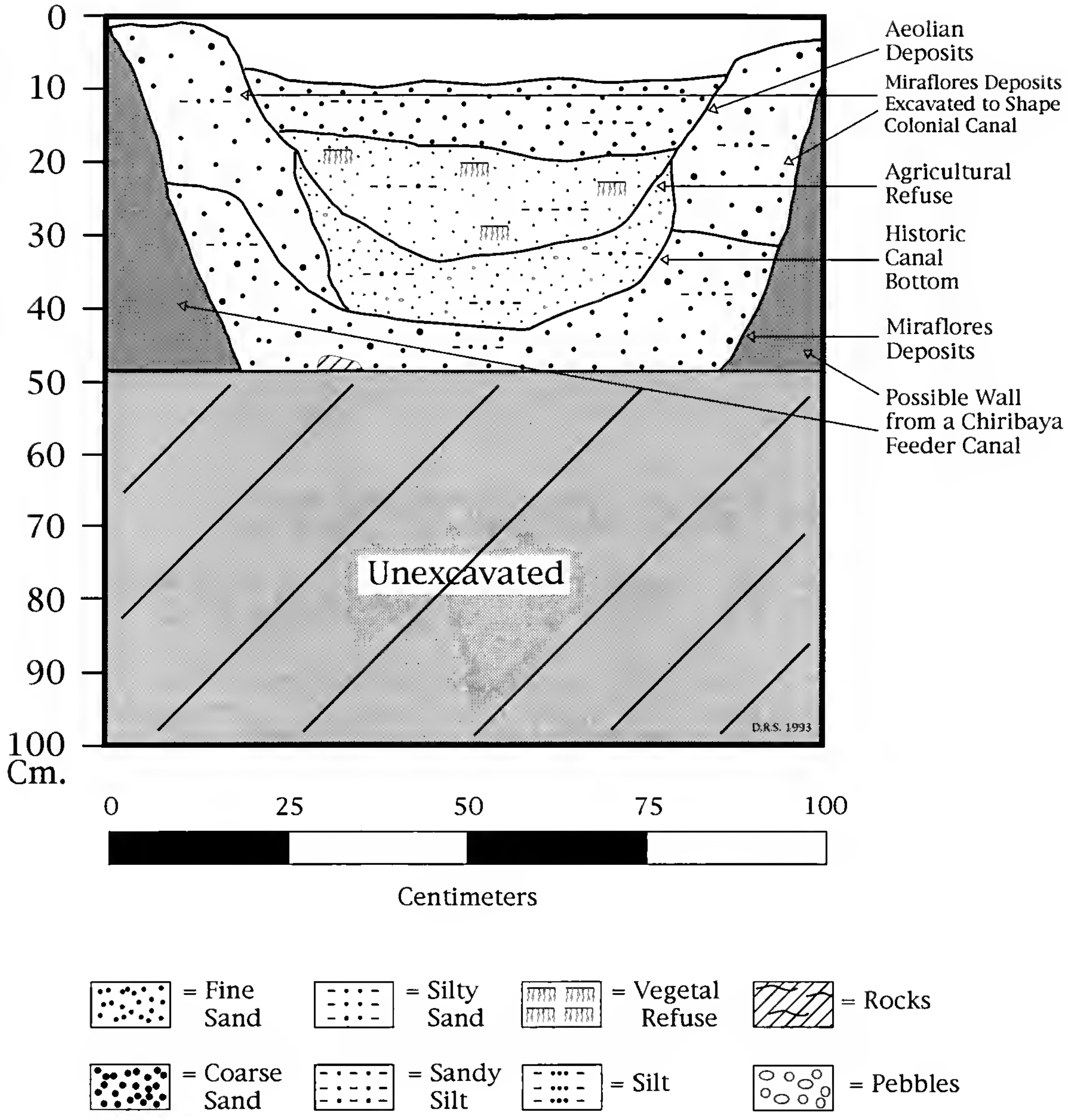

Figure 7-29: Profile of Historic Canal at Planting Surface #1

Ilo River. This canal was rendered useless by the Chuza Flood because five meters downvalley from the trench, the historical canal was barely discernible when I excavated into the quaternary marine terrace on which Planting Surface #1 is located. Only a part of the inside wall of the canal is visible, yet there are two places that Huayna Putina ash can be seen. This canal profile was the only one that I was able to excavate in all of the valley because the entire prehistoric canal and most of the historic canals were either inundated by the Miraflores or the Chuza Flood or totally removed by these floods.

Geologic Column #1

Figure 7-30 shows a profile of Planting Surface #1 and the location of Geologic Column #1. Figure 7-31 shows the salient features of this column. The uppermost deposits are composed of 12 cm of light yellowish brown (10YR 6/4) aeolian sand and silt which overlie the almost 1.5 m thick pale brown (10YR 6/3) Chuza deposits from the lateral quebrada consisting of coarse sand, numerous rock fragments, and a number of rocks up to 20 cm in diameter. The number of large rocks included in the Chuza deposits is not consistent with these same flood deposits examined in the coastal quebradas. The reason for this difference is that the deposits in G. C. #1 are from a much shorter lateral quebrada which did not allow the flood enough time to deposit the larger rocks farther upslope, like the longer drainage systems did at the Carrizal and Miraflores Quebradas.

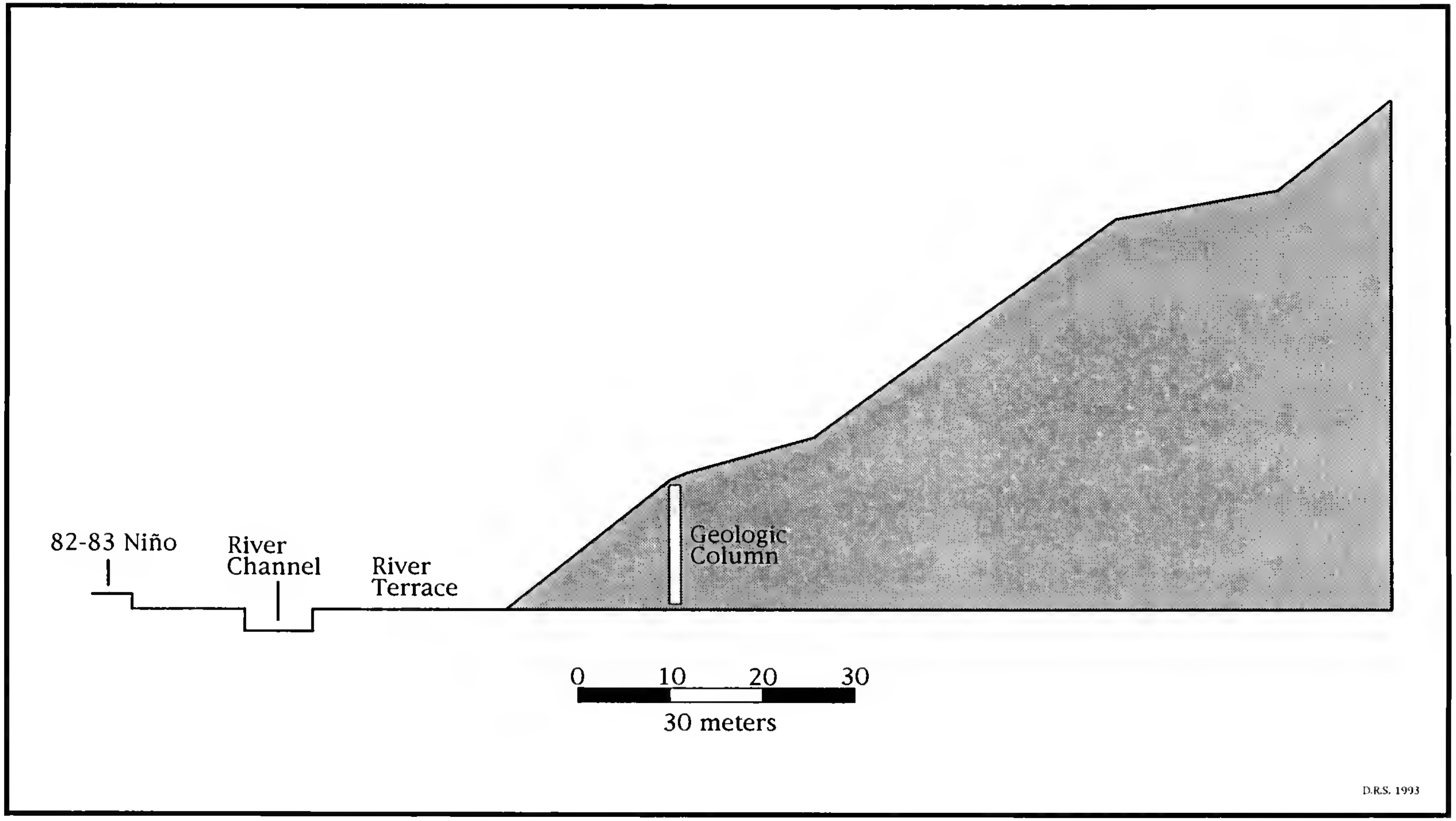

Figure 7-30: Profile of Planting Surface #1

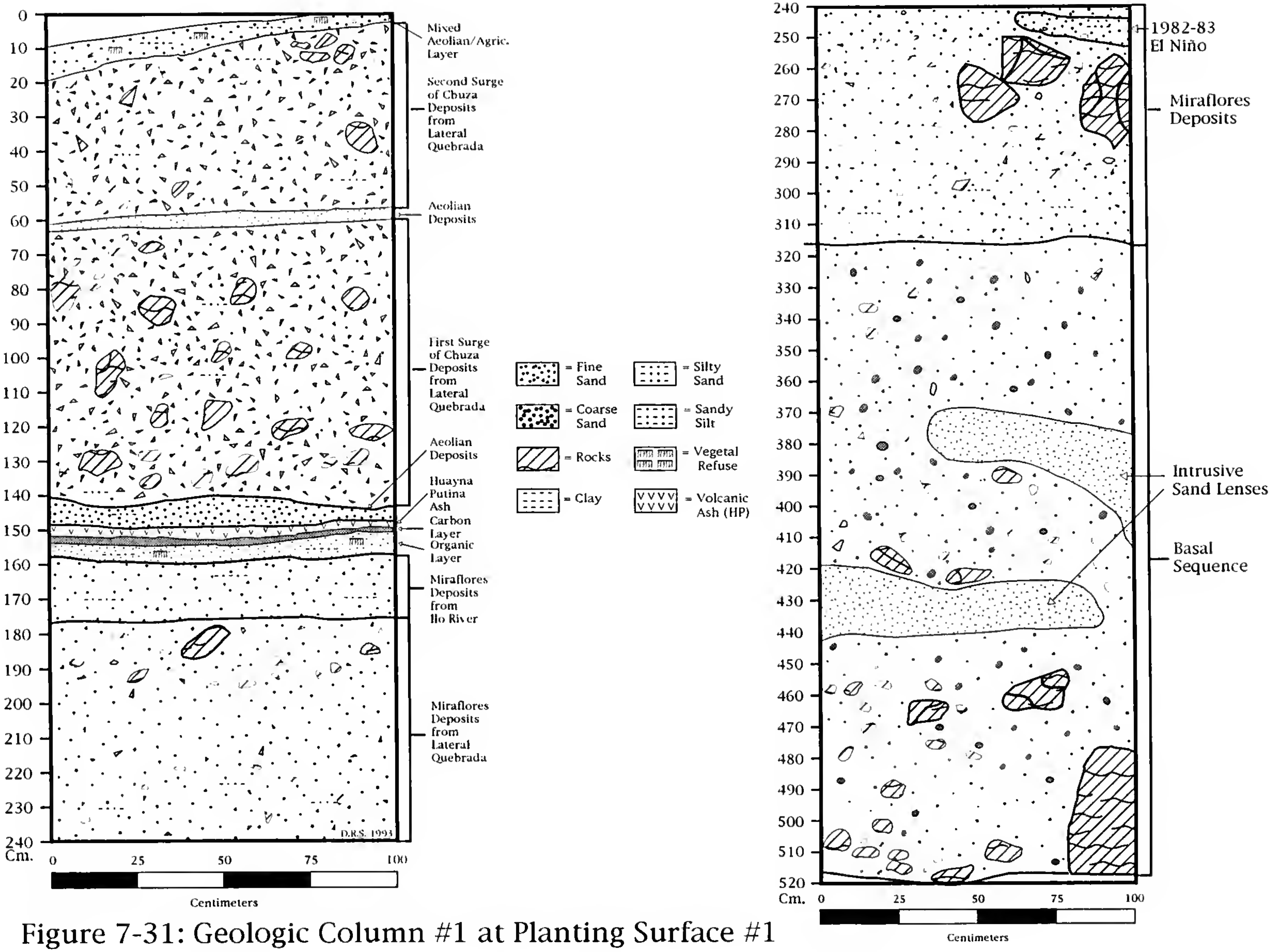

Figure 7-31: Geologic Column #1 at Planting Surface #1

Immediately beneath the Chuza debris is a 2-3 cm light gray (10YR 7/1) layer of Huayna Putina volcanic ash, which has a 3 cm dark gray (10YR 4/1) layer of carbon in direct contact with the ash. The heat from the tephra and possibly an accompanying fire caused the upper few centimeters of the Miraflores deposits to turn to a pinkish white (5YR 8/2) color. The remaining 20 cm of the river-deposited Miraflores sediments are very pale brown (10YR 7/3) fine sands and silts with no rocks. Beneath these fine pale brown sediments are 2.20 m more of other Miraflores light yellowish brown (10YR 6/4) deposits, which contain sand, silt, some rock fragments, and rocks as large as 25 cm in length. There are no massive rocks here because the quebradas joining the river valley from the South are very short drainages compared to those drainages found along the coast. Lying 4 m above the river channel are some of the light gray (10YR 7/2) 1982-83 El Niño sand and silt sediments which form a mud cap that covers some of the upper Miraflores deposits. Contiguous to this stratum is the 2+ m of the pale brown (10YR 6/3) Basal Sequence deposits consisting mostly of sand, some rock fragments, marine gravels, and rocks as large as 30 cm. Intruding into the Basal Sequence are portions of two brown (10YR 5/3) sand lenses, which probably resulted from the riverine slackwater phase of a previous flood event.

Discussion

Analysis of the various profiles and geologic columns at Carrizal, Miraflores, and Pocoma Quebradas and also in the Ilo Valley yield similar conclusions concerning the composition of the ca. 1350

A.D. Miraflores Flood and the ca. 1607 A.D. Chuza Flood. Although the color of the Miraflores Flood deposits varies from a dark brown through and including the classic pink, the basic constituents of its flood deposits rarely deviates. Regardless of the location in the Ilo region, the highly compacted sand and silt matrix will usually include some small gravels and rocks, a few rock fragments, and many rocks as large as 50 cm. In addition to those rocks included directly in the flood deposits, there are the gargantuan boulders, some of which are as large as 3 m in diameter, which were also moved downslope and sprinkled liberally across the landscape.

The Chuza deposits vary in color from a dark grayish brown to a yellowish brown depending upon the location. However, once again, despite any color variation there is no mistaking or confusing the Chuza flood deposits with any other flood debris. The matrix will contain less sand and silt than the Miraflores matrix and will vary from the average slightly compacted state to a highly compacted stratum, on very rare occasions. However, it is the inclusion of multitudinous small (.5-2 cm) angular granitic fragments that is Chuza's most identifiable characteristic. The presence of a plethora of small rock fragments in the flood deposits tells the observer that this debris belongs to the Chuza Flood and to no other event.

The profiles and columns at the various locations also contain an equivalent flood record and consistent stratigraphy. The geoarchaeological flood record found in the study area indicates repeatedly that at least two very large flood events have impacted the entire region in the last 700 or so years. The flood stratigraphy demonstrates that the deposits of the Miraflores Flood are always

found underlying those deposits left by the Chuza Flood. Many times volcanic tephra from the 1600 A.D. eruption of Huayna Putina will be found separating the sediments from these two large flood episodes. Generally. the depths of the flood deposits suggest that both the strength and the volume of the Miraflores Flood were several times greater than those of the Chuza Flood. Even though the depth of the deposits from both events may fluctuate somewhat, the Miraflores deposits are consistently 2-3 times deeper than those sediments of its historic counterpart.

The flood deposits were almost always encountered uniformly at all locations, but the depths of these deposits might vary depending upon the topography of the quebrada or may even be absent in certain cases. For example, the higher terraces, whether cultural or agricultural, may not contain any evidence of a flood because the elevation of these surfaces exceeds the maximum height of the flood surge—such as was the case at both the Carrizal and Pocoma Quebradas. Because of impeding obstacles, the main flow of a flood may be forced to split into two parts or to deviate from the original course. An example of a mudflow splitting is found at Carrizal where part of both the Miraflores and the Chuza floods flowed around the slightly higher domestic terraces. However, at the Miraflores Quebrada there was nothing to hinder the flood, and, so, at this location both the Miraflores and Chuza floods continued for hundreds of meters farther downslope than they did at the other two quebradas.

CHAPTER 8
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Calculating the Volume and Speed of the Miraflores Flood at the Miraflores Quebrada

The devastation to the irrigated agricultural system visible in the Ilo Valley and in the coastal quebradas could only have been caused by a flood event of inordinate magnitude. Therefore, in addition to the geoarchaeological and archaeological evidence presented in this dissertation, it is also possible to use the standard mathematical equations of fluid mechanics to prove the enormous size of the Miraflores Flood.

The Chézy-Manning equation ($Q = {}^{1}/_{n} \times A \times R^{2/3} \times S^{1/2}$) is used to calculate the flow rate of liquid, or liquefied masses in our particular case, according to the slope angle (Street and Wylie 1985). The constant of the wall material of the liquid carrying device is designated by "n" in this equation. Since the walls of the Miraflores Quebrada are composed mostly of loose or consolidated sand, some silt, and great quantities of stratified rock and scree, and the Miraflores Quebrada channel consists of gravel, cobbles, large rocks, and boulders, the Manning constant for "rubble" (0.030) was chosen since rubble most closely characterizes the surface of the carrying device of the liquid. It should also be noted that the trapezoid

formed by the quebrada channel and the 30° angled side walls is the shape in which irrigation canals are built because the trapezoid is the most efficient configuration for transporting water in open irrigation canals (Ortloff et al. 1982). The additional possibility of a SCDE (Synergistically Coupled Destructive Event—see below), in which previous tectonic activity had further loosened this rubble, dramatically increases its potential for destruction when coupled with the massive flood surge that would roar down this channel.

The "A" of this formula represents the cross-section of the carrying device in square meters, i.e., the length of the channel and the side walls of the quebrada times the height of the flood flow. Since the flood deposits in the upper quebrada are at least 5 m above the bottom of the channel, we can safely assume that the flow of the Miraflores Flood was a minimum of 5 meters in depth. The width of the quebrada channel is 15 m, with the side walls sloping at 30°. Therefore, the cross-section (A) of the trapezoidal carrying device is 89.45 m^2 (5 m x 17.89 m).

"R" is the hydraulic radius, which is (A/P), with "P", the wetted perimeter of the carrying device, being 26.54 m. Therefore, the hydraulic radius (R) of the quebrada would be 3.370 m.

"S" is equal to the slope angle. Since the mudflow at the Miraflores Quebrada is the most massive extant representation of the Miraflores Flood, the slope angle (10°) of the upper quebrada will be used. This is the angle of the quebrada before it disgorged the Miraflores mudflow which covered the domestic terraces and eradicated the Chiribaya village. The slope (S) of 10° is equal to

.1763. Therefore, the rate of flow (Q) for the Miraflores Flood in the upper quebrada would have been 2,814 m^3/sec.

The average velocity (v) of flowing liquid in an open channel is equal to Q/A. Thus, a wall of water, mud, and boulders at least 5 meters tall would have swept across the Miraflores village with an average velocity of 113 k.p.h. In light of this additional evidence, and the new possibility that this Miraflores "Flood" was actually a far more complex and destructive SCDE, it is worth reiterating that it would have been almost impossible for anyone or anything to have survived such a devastating onslaught—at least in the immediate vicinity of the Miraflores Quebrada itself.

Dating the Miraflores Flood

Since written records concerning Peru are non-existent before the arrival of the Spanish in 1532 A.D., archaeologists must rely on other sources of information to corroborate archaeological data. In the case of dating a prehistoric El Niño flood event, the most reliable source for data regarding Paleo-climatological activities comes from the Quelccaya Glacier in southern Peru. Various inclusions within the ice serve as proxy records of past events. For example, microdust particles trapped within the ice reflect dry seasons or periods of drought, while the composition of heavy oxygen isotopes (^{18}O) indicates wet periods. Furthermore, larger insoluble particles, such as the volcanic ash from the eruption of Huayna Putina, are also encapsulated in the glacier (Thompson et al. 1986), which can be used as a chronological marker for PreHispanic weather anomalies.

Assurance that carbon for ^{14}C dating does not come from a later flood event is provided by a number of chronological constraints. The 1600 A.D. volcanic tephra pre-dates the Chuza Event and must underlie these flood deposits. The inclusion of olive wood in flood sediments would date the flood to possibly no earlier than ca. 1550 A.D. when olives were introduced by the Spanish. The earliest constraints are provided by the Chiribaya cultural materials and the morphologically distinct PreHispanic planting surfaces found throughout the study area. Using these constraints helps prevent the recovery of carbon which could possibly produce spurious dates.

For the late PreHispanic period, these proxy records from the Quelccaya Glacier, with an accuracy of +/- 20 years, indicate that there were strong ENSO perturbations between 1270-75 A.D. and 1350-70 A.D., with 1350 A.D. showing decidedly strong activity. Thus far, we have only one processed ^{14}C sample for the Miraflores Flood which dates the event to around 1350 A.D. +/-45 Yrs. (PITT 0948), but it correlates well with the ice core data. As other possible dates, Wells (1988) interprets two ^{14}C dates of 1325 A.D., and 1380 A.D. as an approximate date of 1330 A.D. +/- 35 for a major north coast El Niño, which probably was the Miraflores Flood. Wells (1990) offers two additional ^{14}C dates of 1330 A.D. +/- 60 and 1376 A.D. +/- 135, which probably refer to this same flood event. Pozorski (1987) has ^{14}C dates that suggest ca. 1300 A.D. for a major north coast flood event. Regardless of the tolerances for these various ^{14}C dates, they all tend to corroborate the dates from the glacial ice cores. Thus, all data to date strongly indicate that the Miraflores Flood occurred around mid-14th century A.D., plus or minus a few decades.

Flood Impact on the Agricultural System

The coastal quebradas and the Ilo Valley are ideal settings from which to recover archaeological evidence concerning the devastation caused by the 14th century El Niño flood because the flood deposits are found most everywhere. In addition, destruction to the irrigation canals and terraces is quite apparent. The overall flood impact to the Chiribaya agricultural infrastructure was swift and pervasive. The agricultural systems in the quebradas and in the Ilo Valley were rendered instantaneously useless by the Miraflores Flood.

Even if there had been a sizable population which survived the flood, the destruction was such that it would have been virtually humanly impossible to make the once impressive irrigated agricultural system operable, though there are some who might disagree. For example, a modern study shows that two humans can build a 100 m x 3 m x 2 m high terrace in 43 days (Guillet 1987b:41). This estimate may be accurate under optimum conditions, but it still seems that, for the Chiribaya people, two humans would be hard pressed to remove hundreds of tons of flood debris from a buried irrigation canal, which is an integral part of any agricultural system located along the Peruvian desert coast.

As previously stated, one of the possible reasons that the Miraflores Flood was so devastating is that the severe El Niño which produced it may have actually been a prolonged event. Ice core data from the Quelccaya Glacier indicate a 20 year period of ENSO activity from 1350-1370 A.D. (Thompson et al. 1986), which could mean that

the Miraflores Flood was the result of a multiple-year El Niño. In contrast to other natural disasters, such as earthquakes, which are often localized, very strong El Niños can be either regional or PanAndean in extent. The interworkings of tectonism and El Niños, as applied to the coastal quebradas and the Ilo Valley, could be termed Synergistically Coupled Devastative Events (SCDE). The combined destruction of a strong El Niño, preceded by tectonic activity, can be far greater than the destruction from either individual event alone. Thus, in the case of these SCDE occurrences, the whole is much larger than the sum of its parts and actually becomes an entirely new category of natural disaster, which has been identified, defined, and measured for the first time in this present study. Furthermore, the tectonic activity need not be of major proportions, since minor tremors, within the range of 4-5 on the Richter Scale, have sufficient force to dislodge the friable, unstable materials that occupy the steep (25°-30+°) valley walls in both the Ilo Valley and the coastal quebradas. Certainly this set of SCDE conditions was the case for the Chuza Flood based on historical records and, based on the abundant evidence, it was probably also the case for the Miraflores Flood.

Declining Demographics

Owen (1991) suggests that the local population in the Ilo Valley had declined as much as 80% by the mid-thirteenth century A.D. The impact of the Miraflores Flood should have wreaked havoc on such a small population. Disease and other pestilences would have proliferated almost beyond belief, based on the data concerning the

aftereffects of a modern event as presented in Chapter 2. Since their agricultural system was destroyed, the Chiribaya population would have also been severely debilitated by hunger and vulnerable to outside influences, which is probably the reason that the Estuquiña people emigrated from the highlands into the Ilo area following the Miraflores Flood.

Impact on the Chiribaya Culture

The archaeological record found in the study area of the three quebradas and in the Ilo Valley presents undeniable evidence that an immense El Niño perturbation had swept down upon this region around the mid-14th century A.D. The question of whether the Carrizal Quebrada, or any other quebrada, was occupied at the time the flood event took place is a moot point because there is incontrovertible evidence at the Carrizal quebrada and at the Pocoma Quebrada that there was at least a remnant post-flood population still living in the area who could excavate enough flood deposits to build a finely structured domestic terrace wall. Granted we are currently unable to ascertain the date that this terrace wall was built, but this is only one reason that additional research is so badly needed in these coastal quebradas.

The overall impact of the Miraflores Flood on the Chiribaya Culture must have been nothing less than devastating. Although flooding and mudslides caused by the 1982-83 El Niño killed hundreds of people in Peru, and despite the fact that it was the largest perturbation in the last one hundred years, the resultant

flooding from this 20th century event was trifling when compared to the 14th century Miraflores Event which literally buried many locations throughout the Ilo area under tons of mud and massive boulders. It would be more than 150 years in the future before native Peruvians would witness a comparable rapid devastation, only this time it would be caused by the introduction of New World diseases.

The effect on the Chiribaya Culture, which gained its autonomy during the Late Intermediate Period (Jessup 1991), was especially profound because "phenomena that alter subsistence systems and disrupt means of agricultural production are likely candidates for triggering change . . . " Moseley 1987:7). Apparently claiming that a single flood event could have caused a drastic change in the local culture near Ilo is considered insignificant by some archaeologists when compared to the impact of a religious movement (Barkun 1974; Conrad and Demarast 1984) or military invasion (Pozorski and Pozorski 1987) as the underlying cause for radical cultural change. Yet, what could be more "dramatic" than a gigantic wall of mud, thundering down from the mountains, to sweep whole villages literally off the surface of the earth into the Pacific ocean and to bury others so completely that, Pompeii-like, they have lain entombed for centuries awaiting our shovels? Surely such a cataclysmic event must produce both instantaneous and long-range changes in the culture of any surviving peoples.

To date no evidence has been found in the Ilo area to support either of the other two theories. Since there are no new

religious icons found on the unadorned post-flood pottery, it seems that no fresh religious fervor was felt during the aftermath of the flood, and military invasion can also be effectively ruled out since there is no evidence of battle trauma present in any of the many intact "*fardos*" (mummies) recovered from the Chiribaya tombs (Williams 1990). Therefore, based on the evidence presented in this dissertation, the devastation caused by the Miraflores Flood is still the most reasonable explanation of why the Chiribaya Culture, which had held sway over much of this region for almost 4 centuries, would abruptly change.

Cultural Responses to the Miraflores Flood

Paulsen (1977) has claimed that any major climate shift should affect cultures in such a way that archaeologists should find evidence of changes in their subsistence base, settlement patterns, or artifact assemblage. This idea certainly seems to be borne out by my investigations of the Chiribaya Culture because, after the Miraflores Flood, there were several noticeable changes in the archaeological record. For example, at the San Geronimo site, located on the Ilo river about 100 meters from the Pacific Ocean, there is evidence indicating that the local people had to revert to their earlier maritime subsistence strategies after the Miraflores flood totally destroyed their irrigated agricultural system in the Ilo Valley. Grave accompaniments, recovered from the intact burials, included model boats, fishing hooks, and nets (Jessup 1990, 1991). These types of grave goods are commonly found in association with other fishing

society burials elsewhere in Peru (Bird 1941). There were a few storage units which contained thousands of tiny dried fish which were probably anchovy (*Engraulis ringens*), indicating "mass-capture" by fishing nets. Further proof of a sudden cultural change is the fact that this site had been abandon earlier by the Chiribaya and was re-occupied some time after the Miraflores Flood (David Jessup, personal communication 1991).

The presence of a maritime artifact assemblage at Burro Flaco could also be interpreted to mean that the once agricultural-based Chiribaya Culture had again become fisherfolk. There is ample evidence that the occupants of this site relied heavily on maritime activities because metal fishhooks and fishing weights for nets were recovered from excavations at this site. It would be difficult to argue for any subsistence base at this site other than maritime.

Emigration into the Ilo Area after the Miraflores Flood

The evidence of metal smelting at Burro Flaco raises the question of whether another culture brought this technology into the area. Could the art of metallurgy been introduced into the area by intruders from the highlands, where metallurgy has been practiced since at least 500 B.C., or by people from northern Chile, where metal fishhooks were manufactured by much earlier fisherfolk?

DNA analysis of the many human remains excavated in this area could help to identify people who are from the same or different breeding populations, i.e. local Chiribaya people or a highland population. For example, DNA studies should be able to determine if there are any significant genetic differences between

the Chiribaya and the people who occupied the Burro Flaco Site after the Miraflores Event.

Based on the evidence of these investigations, I propose that the technology of metal smelting was introduced by the highlanders who emigrated into the Ilo area after the Miraflores Flood. Further, it was this same people who brought with them the rather plain Estuquiña style of highland pottery, which continued to be used during the Inca occupation. It would be no surprise if the proposed DNA studies confirmed this opinion.

Cultural Change Resulting from Natural Disaster

A severe natural disaster can produce rapid, long-lasting changes within a culture when its agricultural subsistence base is destroyed. The 12th century A.D. Fempellac's Flood on the north coast of Peru ruined the crops and caused widespread famine. As a result of this flood, the local dignitaries revolted against their ruler and threw him into the Pacific Ocean. "Central icons of the north coast Sican Style were systematically purged after calamitous El Niño flooding devastated the Lambayeque region around A.D. 1100"(Moseley et al. 1993:23). The Huayna Putina eruption produced changes in both the Spanish and the native population living in Arequipa. The Spanish viewed the eruption as a punishment by God for their lascivious escapades during Carnival. Whereas, the natives interpreted the explosion as a fulfillment of the prophesy by Taqui Ongoy that the ancient gods would return to destroy the Christian God and the Spanish. As a result, a great deal

of tension between the Spanish and the Peruvians ensued (Bouysse-Cassagne and Bouysse 1984:53-56).

In the case of the Chiribaya Culture, the destruction of the agricultural system by the 14th century flood weakened the culture to such an extent that they were vulnerable to non-Chiribaya people. Since the vibrant Chiribaya iconography was missing on the local pottery and textiles after the Miraflores Flood, we can infer that there was a change in ideology. The former belief system of the Chiribaya had inspired the use of bright red and orange colors and geometrics including stars, circles, and various linear designs. However, the new ideology of the highland immigrants obviously did not embrace surface ornamentation because the Estuquiña pottery and textiles are bereft of decorations.

Recommendations for Future Investigations

Because 1993 is the third consecutive year that an El Niño has disrupted global climate patterns, it seems that much more research into ENSO and SCDE phenomena is needed not just in Peru, but elsewhere in this world. The Peruvian National Meteorological Service theorizes that the contamination of the earth with "greenhouse-effect" gasses is altering the ecological and atmospheric balance (Newman 1993). Thus, by extension, might there not be a correlation between global warming and the increased frequency of strong El Niño perturbations? This correlation between global warming and El Niño events could actually exist because unusual relationships do occur in nature. For example, there is a definite

correlation between the low water level of Lake Titicaca and the 11 year solar sunspot cycle (Mayolo 1992).

Since we are now aware that there is some evidence of re-building in the study area after the Miraflores Flood, such as the cane house built atop the Miraflores deposits, more archaeological research is needed at the Pocoma Quebrada. Additional work is also needed at the Carrizal Quebrada since there are middens buried by the Miraflores Flood. As far as the Miraflores Quebrada which was so totally obliterated by the mammoth flood, there are still interesting questions to answer, such as the true purpose and function of the mysterious large sunken rectangular features. There are also a number of undisturbed collared tombs, encapsulated in the Miraflores sediments, waiting to be examined by archaeologists.

Since my investigations have uncovered evidence of post-flood rebuilding at the Pocoma Quebrada, it is obvious that additional work in needed to determine, if possible, the extent of the settlement and the subsistence activities at this location. Additional research and ^{14}C are definitely required to ascertain exactly how the Burro Flaco Complex fits into the Chiribaya cultural sequence. Other flood studies should be conducted in the other coastal quebradas located North and South of Ilo. Flood research in the Azapa Valley of northern Chile might help to determine the farthest southern extent of the Miraflores Flood and, if flood deposits are present, allow a comparison of the cultural impact on the Chilean subsistence base to that revealed by this investigation, which has added but one piece to the wonderful puzzle that is southern Peru.

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BIOGRAPHICAL SKETCH

My interest in archaeology was piqued at a very early age when I was introduced to the subject in a fourth grade ancient history class taught in a rural, one-room schoolhouse in central Illinois. A few years later I read a story about a sacred *cenote* (well) in the wilds of the Yucatan Peninsula. From that day forward, the only thing I ever wanted to become was an archaeologist. I vowed that if I ever got to college, archaeology was what I would study.

Unfortunately, an opportunity to attend college was not immediately forthcoming. I was 40 years old before I took my first college courses. After completing an A.A.S. degree in computer programming, I continued my education at SIUE where I received a B.A. in Anthropology and Classical Studies. Since attending the University of Florida, I have concentrated on the archaeology of Latin America, and in the last several years I have focused particularly on Peru. In 1990, I spent three months doing research on paleoflood events in southern Peru, and was awarded my M.A. based on this research. I returned to Peru in 1991 to do preliminary dissertation fieldwork.

I appreciate this opportunity to achieve my lifetime dream so sincerely that I have applied myself to my studies with some dilligence and, as a result, I have been the recipient of many honors

Research Award from The Explorers Club, 1991; and the Outstanding Graduate Paper Award from the Florida Academy of Sciences, 1992.

I am eagerly awaiting my return to the field in Peru to continue my research into the severity of prehistoric disasters and their effects on indigenous cultures. These investigations should prove most interesting and, hopefully, will help to unravel the mystery of why some cultures, which have survived quite handily for centuries, suddenly fall from power and fade into historical oblivion.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Michael E. Moseley

Michael Moseley, Chairman
Professor of Anthropology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Linda Wolfe

Linda Wolfe
Associate Professor of Anthropology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Scot E. Smith

Scot Smith
Associate Professor of Civil Engineering

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Barbara Purdy
Professor of Anthropology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the Department of Anthropology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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